BOARD OF TRADE.

DECEMBER 6TH, 1902.

REPORT

ON A

VISIT TO AMERICA,

September 19th to October 31st, 1902,

BY

LIEUT.-COLONEL H. A. YORKE, R.E.,

CHIEF INSPECTING OFFICER OF RAILWAYS.

Presented to both Houses of Parliament by Command of His Majesty.

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CHIEF INSPECTING OFFICER OF RAILWAYS.—BOARD OF TRADE.

TO THE RIGHT HONOURABLE GERALD W. BALFOUR, M.P.,
PRESIDENT OF THE BOARD OF TRADE.

RAILWAY DEPARTMENT,
BOARD OF TRADE,
8 Richmond Terrace, Whitehall, S.W.,
6th December, 1902.

SIR,

I HAVE the honour to forward herewith the diary of my movements and investigations during my recent visit to the United States, made in pursuance of your instructions, and to report briefly on some of the more important matters that came under my notice.

I directed my attention chiefly to the construction and equipment of :—

1. Steam railroads ;
2. Surface lines or tramways, subways, and elevated railways ;
3. High speed electric interurban railways ;

but incidentally I saw many other things of interest.

I.—STEAM RAILROADS.

Construction.—There is a fundamental difference between the modes of construction of English and American railways. In England the bull-headed rail resting in cast-iron chairs is almost universally adopted for lines of heavy traffic. In America the T-rail or (as it is sometimes called in England) Vignoles rail is invariably employed, the rail being secured to the sleepers or ties by means of ordinary spikes. The Americans claim that their permanent way is easier and quicker to lay, cheaper to maintain, smoother to run over, and as durable as the English type. As regards weight of rails there is not much difference between the two countries, the American engineers having now adopted 100-lb. rails, with a base 6 ins. wide, as their standard for heavy lines, as against rails of 80 lbs. and 85 lbs. which were formerly employed. Of course there are in the States many lines with rails lighter than any of the above, but I am now referring only to the more important lines, on which heavy rails are found to be necessary. In England the weight of rails for main lines now varies from 85 to 103 lbs., *e.g.*; those used by the London and North-Western Railway

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Company weigh from 90 to 103 lbs.; by the Great Western Railway Company from 92 to $97\frac{1}{2}$ lbs.; by the Great Northern Railway Company 92 lbs.; and by the London and South-Western Railway Company 85 lbs. The English railway chair weighs from 40 to 54 lbs.

In America the number of sleepers or ties is greater than in England, but the difference between the practice of the two countries is not so great as is sometimes supposed. In America the average number of ties employed with heavy rails is 14 or 16 to a 30-ft. length of rail, and 18 with light rails of the same length. In England the number of sleepers used is 12 to a 30-ft. length of heavy rail. The average dimensions of an American tie are, 8 ft. long, 8 ins. wide, and 7 ins. deep. For a 30-ft. length of rail with 14 ties this gives a bearing area as between the ties and ballast of 74·6 square ft., and with 16 ties, 85·3 square ft.

The dimensions of an English sleeper are, 9 ft. long, 10 ins. wide, and 5 ins. deep. This gives a bearing area for the same length of track of 90 square ft. The advantage in this respect is therefore with the English practice.

Again as regards the bearing area of the rails on the ties, the American method with 14 ties gives 14 by 6 ins. by 8 ins. = 672 square ins. for one 30-ft. rail, or with 16 ties, 768 square ins. The English chair for heavy rails has a base of 105 square ins., so that 12 of these give a total area of 12 by 105, or 1,260 square ins. Here again the advantage is with the English method.

It must however be noted that the American ties are of hard wood, such as oak or chestnut, and are therefore better able to resist the pressure of the rails, than the English sleepers of Baltic timber.

The lateral support afforded to the rails by the English chair is of the greatest value especially on curves, and in America the absence of chairs renders it necessary to use rail braces, which are of the nature of small steel brackets or struts, to support the rails at any place, such as a curve or switch, where there is much lateral pressure. It is also usual in many places to employ bearing plates, or tie plates, between the rails and the ties so as to increase the bearing of the rail on the tie and to afford mutual support to the spikes. The effect of these tie plates however is to shear off the heads of the spikes. The fact that these additions are found to be necessary, shows that the American mode of construction is lacking in certain elements of stability, which are inherent in the English type of permanent way.

The Americans do not place their rail joints opposite each other as we do in England, and there is a good deal to be said in favour of the American practice in this respect. The joint is admittedly the weakest part of the permanent way both vertically and laterally, and it can hardly be doubted that it is an advantage to make the rails break joint, so that the weak spot on one side of the track, shall be supported by the continuous rail on the other side.

Perhaps the detail most open to criticism in the American permanent way is the use of spikes, in the place of screws or fang bolts, to fasten the rails to the ties. These are constantly working loose, and then have to be driven home again. When this process has been often repeated, the holding power of the spikes must be diminished. But with hard wood ties this defect is not so serious as it would be with the soft wood sleepers used in England. In fact hard wood seems to be essential for the American style of permanent way. If this be so, there would probably be no economy in England in adopting American practice, for the extra cost of the ties would more than balance any saving due to the omission of chairs. The American road would, I consider, be vastly improved, if some form of fang bolt with rail clips were used instead of spikes, for fastening the rails to the ties.

As to the cost of maintenance, I cannot help thinking that the English method must give the best results, but many factors, such as the difference in the prices of labour and materials, and in the nature of the traffic, have to be taken into account.

The ballasting of the heavy lines in America, so far as I saw them, is as good as anything to be found in England, and there is no doubt that as a rule

railway travelling in America is smooth and quiet, a feature which, though partly due to the road, may be also partly attributable to the invariable use of long and heavy bogie coaches.

Movable frogs or crossings are largely used in America, and give general satisfaction. In England they are almost unknown, though the London and South-Western Railway Company are now experimenting with them. Their advantage is that they abolish gaps in the rails, and therefore enable crossings to be laid with much flatter angles than are possible with fixed crossings, besides affording smoother running. They are not unlike a combination of facing and trailing points, and are operated by levers in a signal cabin, and should be interlocked with the signals. As they are heavy and require a considerable force to operate them, they are specially suitable at places where a power plant has been installed for operating the points and signals.

Spring frogs are also common, but opinion is divided as to their merits. Some engineers assured me that they had no trouble with them, while others say that the springs are liable to break, and that under such conditions they may cause a derailment.

Signalling.—Signalling in America is in an inchoate condition, there being no uniformity of practice throughout the country. Some portions of the principal railroads are fully signalled, but on many others hardly any signals are used, and even where signals are used, their shapes, colours, and meanings vary upon different lines. Signals are divided into various classes in a manner unknown in England, such as Automatic signals, Interlocking signals, Telegraph block signals, Train order signals, &c. Similarly with block working, only about 25,000 miles out of a total mileage (measured as single track) of 200,000 are at present worked in America on the block system, but its use is being gradually extended. Block working, however, is not so strictly interpreted as it is in England; two or more trains are constantly permitted to be in the same section at the same time, and trains are allowed under certain conditions to travel in either direction on either track, even where the lines are doubled or quadrupled. On two occasions it occurred to the train in which I was travelling, to be switched across from the proper track to the wrong track, without any halt, and without any formalities other than the handing to the driver or conductor of a train order, giving him instructions to travel on the wrong track, regardless of opposing trains. On both occasions we travelled in this way for several miles at a high rate of speed, there being of course no signals for the guidance or control of the train. Such a mode of working must be dangerous, as the least misunderstanding between the men who give and receive the train order, or any negligence on their part must lead to an accident.

Single lines, which form the bulk of the railroads of America, are operated almost entirely on the "train order" system, no train staff or tablet being used as in England, there being no less than 13 standard forms of "train orders" in use. The train order system was tried in England, and has long ago been abandoned as troublesome and dangerous, and I believe that the American train service would be probably conducted with greater punctuality and economy and certainly with greater safety, if the electric staff or tablet system were introduced on the single lines.

For some time past American railroads have been using automatic signalling, about which a great deal has been recently said in England. The main (four track) lines of the Pennsylvania railroad between New York and Pittsburgh are signalled in this fashion, and so are parts of several other railways. The New York Central Company are also about to adopt it in the neighbourhood of New York, and its use will doubtless extend. Recently in England the London and South-Western Railway Company have equipped a section of their line between Grateley and Andover with automatic signals, and preparations are also being made on the North-Eastern railway for testing this mode of signalling.

The most modern and satisfactory mode of applying the system is by means of a "track circuit." A low tension current flows from a battery along one rail of the track through a relay, and back to the battery along the second

rail. The relay makes and breaks a local circuit, which by means of electro-magnets controls the mechanism, electric or pneumatic or whatever it may be, for operating the signals. When the current is flowing along the line the relay completes the local circuit, and signal is held "off." When, however, an engine or vehicle with metal wheels and axles is in the section a short circuit is established in the track circuit, the relay becomes inoperative; the local circuit is broken, and the signal returns to danger. By insulating the rail joints at intervals, the line is divided into sections, to each of which a separate current is supplied, and signals are placed at the commencement of each section, by means of which the driver of an approaching train is informed whether the section ahead is clear or not. It must be borne in mind that a fundamental difference exists between "manual" signals, and "automatic" signals, in that the former have human agency and human intelligence behind them, and convey a direct order to a driver as to what he is to do, whereas the latter merely tell him the line is clear for a short distance ahead.

In America the sections for this system of signalling vary in length from about 700 yards to 1,300 yards, the average being 1,000 yards. As at the commencement of each section two signals (a home and a distant) are erected for each line of rails, signals become exceedingly numerous, and whereas the signals on American railroads have hitherto been too few, there is now a risk of their becoming too many. Block working, at any rate in England, means the maintenance of an adequate interval of space between two trains travelling on the same track. Goods trains of great length are now coming into use, and they are not infrequently as much as 800 yards long. With trains of such dimensions the interval of space between two trains may, if block sections are only 1,000 yards long, be as small as 200 yards, which, except at very low speeds, cannot be regarded as adequate. Again, the number of block sections into which a line requires to be divided depends on the number of trains which it is desired to pass over it in a given time. With block sections of 1,000 yards, and trains running at 60 miles an hour, the interval of time, or, as the Americans call it, the "headway" between them may be only 34 seconds, which is clearly impracticable and dangerous. Even at a speed of 20 miles an hour the headway may be only 1 min. 42 secs., and at 10 miles an hour, 3 mins. 24 secs., and as it can only occur at starting points or at terminal stations that it is necessary for trains to follow each other at such brief intervals as these, it is difficult to see the advantage of such very short sections in other parts of a line, where trains have to travel at speed, and where fast trains are mixed up with slow. Signals placed at such short distances apart are more likely to be confusing than helpful to drivers, whose confidence when running at speed must also be lessened by the shortness of the block sections. The only reason that I have been able to discover for the introduction of such short block sections, is that "track circuits" do not work well on sections of greater length, but it is difficult to believe that this defect cannot be remedied.

A difficulty arises in England in connection with such signals, and that is how to deal with them in time of fog. In America fogs are said to be rare,—at any rate no special precautions are taken to meet such an emergency. But here it will be as necessary to provide means for "fogging" automatic signals as any other signals. Men for the purpose will be difficult to find, and if mechanical means are adopted for the purpose, the complication and weight of the signals will be increased, and the mechanism will be more liable to fail. The effect of climate and of weather upon automatic signals in England has yet to be ascertained, and it must be remembered that a signal which fails at any time to give a correct indication is likely to be a source of danger. Probably the greatest risks are to be anticipated from snow, frost, and lightning, any one of which may, under certain conditions, cause a signal to remain at "all right," when it ought to be at "danger." Should that happen, a most serious condition of affairs would exist, the results of which might be disastrous. Even under normal conditions the reliability of automatic signals depends on the most careful and trustworthy maintenance. In America, it is said, that the failures as a rule, result in a signal remaining at "danger," when it ought to be at safety, and as this would be likely to cause delay to the traffic, drivers are instructed,

when they find such a signal at danger, to bring their trains to a stand, and then to proceed forward at caution, without waiting for the signal to be lowered. This rule may be unavoidable, but it is easy to see that sooner or later it must result in two trains being in the same section at one and the same time, which defeats the whole object of block working. Telephonic communication is usually provided, telephones being placed on every second or third signal post, so that in case of a break down, the trainmen can communicate with the nearest signal box.

In England the problem is further complicated by the existence of numerous industrial sidings on the main lines, the points and signals of which must necessarily be interlocked with the automatic signals, and require human agency to operate them.

There is something attractive about the term "automatic signalling," and the conclusion is sometimes hastily arrived at, that its adoption will immediately effect increased safety, greater economy and simplicity of operation, a reduction of expenses, and larger dividends. But the cost of installing a system of automatic signalling is great, involving as it does the erection of a power plant, electric or pneumatic, to supply the power for operating the signals, the laying of pipes, conduits, or cables for the entire length of the line for conveying the power to the signals, the provision of numerous wires, batteries, and relays for controlling the power, and the erection of a great number of signals, and the bridges or posts supporting them. Moreover, if the system is to take the place of an existing installation of manual signals, it is to be remembered that the whole of the latter has to be "scrapped." A considerable advantage, such as a large saving of wages, and a largely increased capacity of the railway must therefore be assured, in order to justify the outlay.

Automatic signalling does not of itself introduce greater safety of operation. It is merely a labour-saving device. No doubt it eliminates the risks due to mistakes of signalmen, but it introduces other risks peculiar to itself, due either to inefficient maintenance, to failure of the mechanism, to weather, and to accidents of various sorts. Moreover, the chief object of a system of automatic signalling must be to enable more trains to pass over a given section of the line in a given time, and more trains under such conditions necessarily involve increased chances of accident.

From what has been said it will be seen that the whole question of automatic signalling requires to be further considered before its applicability to main lines in England can be thoroughly ascertained, and the results of the trials of the system upon the London and South Western and North Eastern Railways, will be of the greatest value in the investigation of the subject.

But in "tubes," subways, tunnels, and especially on electrically operated railways, on which speeds are uniform, junctions and sidings are few and far between, sections short, and which are self-contained, automatic signalling will undoubtedly prove exceedingly useful, and some of the railways in London now being equipped for electric traction are to be signalled in this fashion.

Power working of Points and Signals.—The application of some form of power, pneumatic or electric, to the operation of points and signals, is becoming a common feature in America at places where large signal cabins are necessary. Such installations possess many advantages, reducing the physical labour to a minimum, and rendering it possible to employ fewer men. They also economise space and abolish all rods and wires from the station yards. The chief, if not the only, objection to them is their cost, which in the first instance is much greater than that of an ordinary manual plant, and it is simply a matter of calculation whether at any particular place the economies to be derived from such an apparatus balance the initial cost. There are two systems in general use, viz., the electro-pneumatic and the low pressure pneumatic. In the former the movement of the points or signals is effected by air at 75 lbs. pressure, which is admitted to cylinders containing pistons connected to the switches (or signals) by means of valves which are controlled by electric currents. In the latter the mechanism is operated by air at 15 lbs. pressure, the valves being controlled by

a secondary air supply at 7 lbs. pressure. In England a large installation of a similar nature has lately been erected by the London and North Western Railway at Crewe in which the motive power, as well as the controlling agency, is electricity. The North Eastern Railway and Lancashire and Yorkshire Railway Companies are at the same time about to test the electro-pneumatic system, and the London and South Western Railway Company are trying the low pressure air method. It will therefore soon be possible to compare the results obtained by these three systems.

Rolling Stock.—Probably the feature of American railways which at first sight makes the most impression on a stranger is the colossal size of the engines and cars employed thereon, and to this is due much of the correspondence which at intervals fills the columns of the papers concerning American methods of handling traffic. There is no doubt that the engines are very big, some of them standing 16 ft. high above rail level, and many more of them 14 ft. 6 in. and 15 ft. Such engines have great power and are able to haul trains of great weight and length. In the early days of American railroads over-bridges and tunnels were almost unknown, and now that such are being constructed, they have to accommodate themselves to the rolling stock, instead of the rolling stock to the bridges, as in England. In America over-bridges are built 18 ft. above rail level, whereas in England the height of such works is as a rule only 14 ft. 3 ins. above the rails. Moreover, on double lines in the States the space between the tracks is 7 ft., against 6 ft. in England. It can therefore be understood that what is possible in the one country is impossible in the other, and we can never hope in England to equal America in the size of our engines or cars.

A great deal has recently been said about the long freight cars used in America, and English railway managers have been criticised for not adopting cars of equal dimensions in this country. I think some misapprehension occasionally arises on the subject. The important factor in the case is not the length of the car, but the carrying capacity of the car in relation to its weight. American freight cars are all carried on bogies, and as a rule there are eight wheels to a car. Their carrying capacity varies from 30 to 50 tons, and their "tare" weight from 15 to 20 tons. One of the most popular forms of car at the present time appears to be the 50 ft. steel framed car with a capacity of 50 tons (of 2,000 lbs.) and a tare of about 20 tons, the total weight per axle being 17 tons 10 cwt. So long as these proportions are adhered to it makes no difference, so far as the cost of transportation is concerned, whether the load is carried in one car with eight wheels or in two cars with four wheels each. That is to say, the result will be the same if, instead of one car of the size and weight mentioned, two cars are employed, each with a capacity of 25 tons and a tare of 10 tons, and each having four wheels. Not all the cars in America offer such favourable conditions as those just mentioned. The box cars have as a rule a carrying capacity of 30 to 40 tons and a tare of 16 to 18 tons; the paying load in these cases having a less proportion to the dead load than is the case with the 50 ton cars.

There are serious difficulties in the way of introducing for general service in England wagons of great length. The sidings, goods sheds, weigh bridges, turn tables, coal tips, screens, &c. are as a rule quite unsuitable for wagons of the dimensions named, to say nothing of the usual conditions of trade which are based on the present style of vehicle. It is sometimes suggested that English companies should forthwith reconstruct the whole of these works and appliances, but no one has as yet estimated what the cost of such alterations would amount to. It is probably incalculable, and the question arises, whether after all this vast expenditure had been incurred and the whole trade of the country had been disorganised during the transition period, the saving in handling the traffic would pay the interest on the outlay.

The four-wheeled wagon will therefore in all probability remain the standard wagon of the country, and economy is to be sought in improving the design of such wagons and increasing their carrying capacity in relation to their tare, rather than in introducing wagons of greater length.

There is no reason why this should not be done, in fact it has already been accomplished on some railways. Both the London and North-Western Railway and the Great Western Companies Railway have lately built four wheeled wagons, having a capacity of 20 tons, and a tare of about eight tons, which gives the same proportion of paying load to dead load, as an American car of 50 tons capacity.

Another argument against the employment of very long cars or wagons is, that in the case of a derailment or collision the results would be more serious, and the removal of the wreckage would be a much more difficult operation than at present.

There is also the difficulty to be considered due to the private ownership of the bulk of the wagons used upon English railways. This, though serious, need not perhaps be regarded as insuperable, as if the railway companies throughout the Kingdom were unanimous in adopting wagons of a new design, means could be found, perhaps with the assistance of the Legislature, either to abolish privately owned wagons, or else to compel the owners thereof to adopt whatever type of wagon was found to be beneficial to the trade of the country.

It is not suggested that long wagons will never be used, as it is evident that for some purposes such wagons are desirable or even necessary. But for ordinary trade purposes in this country the four-wheeled wagon, of improved design and increased capacity is, I believe, the best suited.

The wheels of American cars, both passenger and freight, are smaller than those used in England, being only 33 inches in diameter, instead of 36 inches as in England. It seems worth consideration, whether 33-inch wheels might not with advantage be introduced in England for goods wagons. This would enable an additional depth of 3 inches to be given to the wagons thereby increasing their capacity without adding to their height, and would at the same time lessen their weight, and effect some economy in their first cost. All the wheels of American freight cars, and occasionally also of passenger cars, are of cast iron with chilled rims. They are not turned in a lathe or machined in any way, but are used just as they come from the foundry. When the wheels are worn out the manufacturing company takes them back at a fixed price, breaks them up, and recasts them. The net cost of such wheels to the railway company is, therefore, very small. Recently fractures of these cast iron wheels have increased in number, and it is a question whether, as at present made, they are suitable for the increased loads put upon them by the introduction of heavy cars. Improved modes of manufacture may overcome this defect, or wheels with cast iron centres and steel tyres or wheels wholly of steel, may become necessary.

Couplings.—The law of the American Congress relating to the use of automatic couplings and air brakes on all freight trains engaged in inter-state commerce came into full force on the 1st August, 1900, and the fifteenth annual report of the Inter-State Commerce Commission, published in 1902, is a highly interesting document. From this it appears that the coupling mechanism is still far from perfect, especially in regard to the uncoupling attachments. Another "common defect in couplers, and one which is the cause of much trouble and expense to the railroads, is the breakage of the 'knuckle.'" The Commissioners are evidently not satisfied with the couplers as at present used, for the report says, "it will be seen that the needs of the future, in respect to couplers, may be described under the heads of strength, simplicity, and finish."

Air brakes.—The same report contains some severe criticisms on "the present condition of the air brakes on the freight cars of the country, the lack of thorough training and discipline of the men in charge of trains, and the insufficiency of the forces assigned to inspection and repair"; the result being that "some companies, more particularly in the east, are still controlling trains on steep descending grades by the use of the hand brakes." This is in accordance with what I saw on the Pennsylvania Railroad, where numerous heavy coal and goods trains were being taken down the Horse Shoe incline by means of the hand brakes, the brakesmen having, in consequence, to run about on the roofs of the cars while the trains were

in motion, a practice which is highly dangerous and a fruitful cause of accident to the train men. One reason assigned for this non-use of the air-brake on such inclines is that the driver may by repeated application and release of the brakes exhaust all the air in the air reservoirs. It then becomes necessary for him to re-charge them, and the doing so releases all the brakes, during which time the train may gain a dangerous degree of speed, and get beyond control. To overcome this difficulty "retaining valves" have been introduced for partially controlling the air pressure in the brake cylinders during the process of re-charging the reservoirs. These retain a pressure of 15lbs in the cylinders during the time that the reservoirs are being recharged, and are described in the report already alluded to as "a device for more efficiently and safely controlling the speed of trains on steep descending grades." "While under favourable conditions the air brake is efficient without this auxiliary, its use is a valuable additional safeguard, and on very steep grades it is a necessity."

Unfortunately the handles for operating these retaining valves are on the roofs of the cars so that their use still renders it necessary for the train men to be above. As the number of bridges over the railroads is increasing, the danger to the men on the tops of high cars becomes greater, and a primitive arrangement for their protection is a common feature on American railroads. This consists of a rope supported on posts and stretched across the tracks on either side of an overbridge. From this rope depend short vertical lengths of thinner rope at close intervals, their lower ends being about the level of the underside of the bridge. The idea is that a man on the top of a high car would be struck by one of these ropes, and warned of the neighbourhood of the bridge in time to avoid the danger.

The law does not render it obligatory on the companies to use the air brake on all the cars of a freight train, but only on so many as will enable the driver to have sufficient brake power at his disposal for controlling the train down the inclines. This partial use of the air brake is a cause of accidents, for when the brake is brought into operation on some of the cars of a train, the cars not so braked are by their momentum forced against those that are braked, with such violence as to crush, and sometimes derail one or more cars. The law in this respect seems to require amendment. If the air brake is to be used at all on freight trains, it should be operative on every car.

From the above facts it will be seen that the problem of safely working heavy American freight trains down steep grades by means of the air brake has not yet been entirely solved. And when it is remembered that some of the large American engines require three men on the foot plate, viz., driver, fireman, and assistant fireman, and that the train crew consists of a conductor and two, three or four brakesmen, it may be questioned whether the economies claimed for the American methods are as great, as is sometimes hastily assumed.

Grade crossings.—It is interesting to note that American railroads are imitating English practice in one respect, and that is in the abolition of level or grade crossings. Enormous sums of money are now being spent with this object. This is specially the case on the Pennsylvania Railroad. on which line some very large works such as viaducts, bridges, and deviation lines are in progress for the purpose of raising the tracks above streets and roads, and for improving grades and curves. These works are being paid for out of revenue and not charged to capital. The guiding principle followed in America on this much debated question is, I was told, as follows: When a new work, however large, does not tap new sources of revenue, and does not serve a fresh area, but merely improves existing conditions and facilities, the cost is charged to income. When, on the other hand, new districts are reached, and fresh sources of traffic developed, the cost is charged to capital. To what extent the cost of works, such as those I saw in progress, amounting as they do in many places to a complete re-alignment and reconstruction of the railway, can be legitimately be regarded as a charge against ,income I cannot say, but it is not surprising that the shareholders should grumble at being called upon to make such sacrifices for the benefit of those who will succeed them. I heard one argument

advanced, which, if not openly avowed, may have an occasional influence on American railway finance, viz., that as American railways were built almost entirely with money raised on bonds or debentures, and that as the ordinary stock, to a large extent, merely represents "paper," there is no obligation on those controlling the line to do more than pay the interest on the bonds and debentures, and that the ordinary stockholders have little or no moral claim to consideration.

Railway Service.—In the mode of selection of men for employment upon railways, and in the opportunities for advancement offered to them, the American railways are ahead of English companies. The following information on this matter was given to me by one of the chief railway officers in the States.

"Applicants for employment must be of sound health, free from physical, mental, or moral infirmities, and must produce satisfactory evidence of previous record, character, and ability. Employés are selected from applicants whose character, intelligence, physical capacity, and general appearance indicate that their services will be efficient and satisfactory, and who are likely to develop ability sufficient to merit advancement in the service.

"All employés are regarded as in the line of promotion, and examinations for promotion are held from time to time as may be required.

"Applicants who fail on the first examination must within one year make written application for re-examination. Those who fail on the second examination will be dropped from the service.

"Flagmen, brakesmen, and firemen who do not apply for examination within five years may be dropped from the service.

"The object of fixing a limit of five years to the term of service of a flagman, brakesman, or fireman is that these occupations are considered as preparatory training for the positions of conductor and engineman, which are the fixed types of employment in the transportation service; and a person who has not the capacity to qualify for either of these positions after five years' service is not likely to do so at any time, and should make way for those who are more capable and progressive."

In this way it happens that every man employed upon an American railway has the road open to him to rise to the highest positions, and many of the most prominent men in the railway world have so risen.

II.—Surface Lines, Subways, and Elevated Railways.

Surface Lines.—I examined the surface lines and tramways in a great many cities, viz., New York, Brooklyn, Washington, Boston, Pittsburgh, Detroit Buffalo, Toronto, and Chicago, and was interested to find that grooved girder rails —such as are invariably used in England—are being almost universally adopted for lines in the public streets, in place of the "step" rails formerly employed The latter are a serious hindrance to ordinary vehicular traffic, though they are said to be convenient to heavy lorries, and for this reason are retained in some of the streets in Boston and Pittsburgh. As a rule street railways are electrically equipped on the overhead trolley system, but in New York and Washington the conduit system with centre slot is used, there being objections to the overhead system in the streets of those cities. In all cases the rails are laid upon cross ties, concrete being as a rule placed between the ties, which does not seem to be the best place for it. The use of wood for supporting the rails makes a much quieter track than the English method of laying the rails direct on concrete, but the American method does not enable such a good surface to be maintained on the roadway. English tramways often have a hard and noisy track, and it might be an advantage if a wooden stringer or cushion were placed between the rail and concrete—at any rate an experiment in this direction would be worth trying.

In some cities rails 60 ft. long are used, and as by this means the number of joints, which are invariably a source of trouble, is reduced by 50 per cent., considerable benefit may be expected from their adoption. A similar experiment might with advantage be made in England.

American cars are all single decked, there being no roof seats, but they are wider and generally longer than English cars. I also think that as a rule they have more powerful motors than are usual in England, which is an advantage, as the motor-men have greater control over their cars. Speeds in the city streets are about the same as in England, but in the suburbs are higher than are usual here. The life guards are indifferent, and accidents are numerous, though no records are obtainable on the subject. As a rule the hand brake only is used, though in Pittsburgh, where grades are severe and speeds high, the Newell magnetic slipper brake is fitted to the cars, and is in regular use. This brake is, I believe, a most useful appliance. It consists of a "slipper" which is practically a horse-shoe magnet, and which is energised by current from the motors, when the latter are acting as generators, *i.e.*, when the current from the trolley wire is cut off. Care must be taken not to cause the wheels to skid by means of the hand brake, as when the wheels cease to revolve no current is generated by the motors and the magnet is not energised. In Chicago the Christensen direct air brake is adopted, but here three and four cars are allowed to be coupled together.

Elevated Railways.—Of the elevated railways of New York, Brooklyn, Boston, and Chicago it is not necessary to say much, as they are not likely to be imitated in any English town. They are noisy and unsightly, and the columns supporting them occupy a great deal of street space and constitute a hindrance to street traffic. They are all, with the exception of that in New York, operated entirely by electric energy at 550 or 600 volts, the current being conveyed by a third rail. In New York the elevated railway has hitherto been worked by steam locomotives, but electric traction is being rapidly introduced, and both steam and electric trains are now running on it. It is expected that when the electrical equipment of this line is completed, its capacity will be largely increased, owing to higher speeds, more rapid acceleration, and the use of longer trains.

The Boston elevated lines are equipped with automatic (electro-pneumatic) signals, and with triggers working in conjunction with the signals, whereby the brakes are applied to any train, which is allowed by the motor-man to pass a signal at danger. The equipment and organization of this line, and the arrangements at certain stations for enabling passengers to change from the tramcars to the railway or *vice versa*, are particularly good.

All trains on the elevated lines are of the multiple unit type, the master controllers being either of the Sprague, Westinghouse, or General Electric Company's pattern, for each of which special merits are claimed. Fairly high speeds are attained, but the numerous sharp curves on all these lines, due to their following the directions of the streets, are a serious drawback.

Subways.—The most recent attempt to solve the problem of urban locomotion is to be found in the subways of New York and Boston, each of which is the outcome of Special Rapid Transit Commissions appointed, in the one case by the State of New York, and in the other by the State of Massachusetts—the former in 1894 and the latter in 1891. These Commissions studied the problem of transportation in and around the cities named, and made specific recommendations for the construction of subways to accommodate either two or four lines of rails, the routes to be followed and the sums to be spent being in each case laid down. It was decided that the New York subway should be worked as a railway, two tracks being reserved for express traffic, and two for local traffic. At Boston it was first intended to devote all the tracks to the use of the surface (or tram) cars. This was subsequently changed, and where four tracks exist two are now given up to the trains from the elevated railway and two to the surface cars. This change of plan was unfortunate, as the grades and curves in the subway, which are suitable for single cars, are found to be detrimental to the trains, causing not only delay, but also undue wear and tear of the wheels, rails, and rolling stock.

As a rule these subways are rectangular in section, but that in New York is now being extended under the East River, by means of a "tube," the internal diameter of which is 15 ft. 6 ins. It is much to be regretted that the "tubes" in London have not been constructed of similar dimensions. The cost no doubt would have been greater, but if the method of financing these works in America had been adopted in London, the increased cost would not have been felt while the advantage gained would have been great.

The cost of the Boston subway was borne by the city, and the Boston Elevated Railway Company, which owns the surface and elevated lines, leases the subway from the city, paying 5 cents for each car passing through, subject to a minimum payment of $4\frac{7}{8}$ per cent. on the cost of construction. The lease is for 20 years. The Company laid the tracks and supply the power and equipment.

The cost of the New York subway is also borne by the city, the Rapid Transit Subway Construction Company being the contractors for the work, and having a lease of 50 years for operating the subway when completed. The contracting company is paid for the work in accordance with their tender, but has to pay in its turn a rental equal to the interest on the bonds issued by the city to provide the funds for the work, and in addition a sinking fund of 1 per cent. by which the principal will be redeemed within the period of the lease. The Company has to provide equipment, power, and machinery, which the city is to purchase at a valuation at the end of the lease. This arrangement is similar to that under which the Chemin de fer Metropolitain of Paris is being built. The advantage of such an arrangement is that, at the end of the period of the lease, the railway is paid for, and becomes the property of the city free of cost. There seems no reason why some similar arrangement should not be arrived at in London.

The Commissions referred to are permanent bodies, and all schemes affecting transportation within the limits of their respective cities have to be submitted to, and approved by, them. For instance, the proposal of the Pennsylvania Railroad Company to construct tunnels under the Harbour and East River, so as to enable their main lines to obtain access to New York City, had to receive the sanction of the Rapid Transit Commission of New York.

The three cities Paris, New York, and Boston afford an object lesson to London. They have faced the problem of urban communication in a business-like fashion, have decided what they want, have arranged for the financing of the work, and have settled the routes along which transportation is to be provided, before allowing the ground to be broken, instead of proceeding in a haphazard fashion, and leaving the most valuable concessions to be scrambled for by private companies. It is much to be hoped, if I may be permitted to say so, that a tribunal will be appointed before it is too late, to consider the congestion of the London streets and to propose a remedy.

The subway in New York is still incomplete, and will not be opened for traffic before the year 1904, but that in Boston has been in use since 1898. In both cases the subways are as near the surface of the streets as possible, and have, as in Paris, convenient stairways to afford access to the stations, no elevators being therefore needed. Such subways are in many ways preferable to deep level "tubes." They are safer, more easy of access, possess a purer atmosphere, and afford conveniences to the public, which are worth considerable sacrifices to attain. What New York has cheerfully suffered and is still suffering to obtain its subway, has to be seen to be believed.

New York has one advantage over London, in that the city is built almost entirely upon rock, and no disturbance is therefore to be feared of the foundations of existing buildings. On the other hand, this rock, which is intensely hard, renders the work of excavating the tunnel a most costly and tedious undertaking.

In one respect I anticipate that the subway will prove a disappointment to the inhabitants of New York, for although it will increase the facilities of travel between the outskirts of the city and the business centres, it will not do much

to relieve the congestion of traffic in the streets. It will mitigate the undue crowding of the cars on the tramways and elevated railway, which is at all times uncomfortable, and occasionally even dangerous, but it will not reduce the number of vehicles in the streets, as there are practically no omnibuses and very few cabs to be affected by it. In London the case would be different, as the construction of a subway or "tube" is sure to cause a diminution in the number of 'buses plying along the same route.

III.—Electric (High Speed) Inter-urban Railways.

Of all the developments of facilities for transportation, the inter-urban lines, which are now such a prominent feature in the United States, are the most interesting and instructive. These are becoming increasingly numerous, every city having a network of such lines radiating from it.

I am not now referring to the mere extensions of the street tramways into the country, though these might be regarded as inter-urban in their character, but to lines of heavy construction and equipment, and specially designed for high speeds. In some instances the lines are branches of the main railroads, which have recently been equipped for electric traction. But in the majority of cases the inter-urban lines have been specially constructed for operation by electricity.

Among branch railways, originally built for steam trains, but now operated electrically, may be mentioned the following examples, which are to be found on the New York, New Haven, and Hartford Railroad, but there are many others :—

(1.) Stamford to New Canaan, 8 miles of single track.

(2.) Hartford to Bristol, 16·6 miles of single track.

(3.) Berlin to New Britain, 3 miles of double track.

(4.) Braintree to Cohasset, 11·5 miles of double track.

(5.) Nantasket Junction to Pemberton, 6·9 miles of double track.

(6.) Providence to Fall River, 18 miles, of which 10 miles are double track.

The first of these to be equipped electrically was the line from Nantasket to Pemberton, in 1895. The New York, New Haven, and Hartford Railroad found at that time that the trolley lines were seriously affecting their revenues, and in order to meet this competition they decided to equip some of their branches electrically. The result of doing this to branch No. 5 was so satisfactory that the process was extended to the other branches, some of which had up to that time been worked at a loss.

The following table, compiled from the most recent available returns, was given to me, and shows the increase of annual passenger traffic due to the change :—

Branch.	Steam.	Electricity.
	Passengers.	Passengers.
1	98,300	184,728
2	367,695	1,060,617
3	267,936	341,207
4 and 5	304,292	702,419

This large increase in traffic may be attributed to the greater frequency of the service, the reduction of fares, and the increase in speed.

Branches 2, 3, and 4 are equipped with the third rail; the others have the overhead trolley. The trains consist of two to five cars, and are run at a schedule speed of 30 miles per hour, with an average of one stop per two miles, the maximum speed being 45 miles per hour. The weight of a motor car is 45 tons, and its seating capacity is 60 passengers.

On the Providence and Fall River Line the trains consist of one, two, or three cars, there being 112 of such trains daily. The service is both local and express, the running time of the local trains with 26 stops being 45 minutes, which is equal to a schedule speed of 25 miles an hour. The express trains with seven stops cover the distance in 33 minutes, which is equal to a schedule speed of 32·7 miles an hour.

The old steam schedule between Providence and Fall River was 48 minutes for local trains with 14 stops, and only 10 trains per day, and there was no express service.

The rolling stock of this branch consists of 46 cars, of which 24 are passenger coaches used as trailers, and nine are combination baggage and passenger cars, the remainder being motor cars. The cars are 40 ft. in length over all. The motor cars have four 80 H.P. motors, and weigh 30 tons.

The wheels on the motor cars are 36 ins. in diameter, having a $1\frac{1}{4}$-in. flange and a 3-in. tread. The rail used weighs 78 lbs. per yard, and the road bed has gravel ballast. The population of Providence is 175,000, and that of Fall River 104,000, and the average daily traffic is 15,000 passengers, the fare for the whole distance being 20 cents, which is half the whole steam fare.

The above description affords a good idea of the results obtained by the operation of unremunerative branch lines of main railroads by electricity.

Of High Speed Inter-urban railways specially built for operation by electricity, I visited four, viz.:

(1.) The Schenectady and Albany Railway.

(2.) The Buffalo and Lockport Electric Railway.

(3.) The Detroit and Port Huron Shore Railway.

(4.) The Aurora, Elgin, and Chicago Electric Railway.

(1) The Schenectady–Albany line is a high speed overhead trolley railway, 17 miles in length, between Schenectady and Albany, $4\frac{1}{2}$ miles of which are within the limits of the two cities. It is a double track located on the public highway, the district between the termini being rather sparsely populated. The population of Albany is 100,000, and that of Schenectady 50,000. The average schedule speed is, for the whole journey, 18 miles per hour, with nine inter-urban stops and about 22 city stops. The schedule speed between the cities is 27 miles per hour, and the maximum speed is 50 miles per hour.

As a rule single cars are used, weighing 24 tons each, and with a length over all of 48 ft. They are equipped with four 50-H.P. motors, and have a seating capacity of 52. The motor truck wheels are 33 ins. in diameter, with $\frac{3}{4}$-in. flange and $2\frac{7}{8}$-in. tread, the axle being $4\frac{1}{2}$ ins. in diameter.

The transmission current is three-phase-alternating at 11,000 volts, the greatest distance to which it is transmitted being 17 miles. The working current is 550 volts direct.

There is a 15-minute service between the two places during the day and evening, and an hourly service during the night. The number of passengers carried is about 3,700 daily, the single fare being 25 cents (1*s.*), and the double fare 40 cents. The New York Central has a steam railway alongside of the electric line, the passenger traffic on which has been greatly reduced since the latter was opened. The fare on the steam railway is 39 cents single ticket. It takes about 55 minutes on the electric railway to travel from the centre of Albany to the centre of Schenectady, and 40 minutes on the steam railway, but the smaller fare and the frequency of the service render the former the more popular route.

There is an "express," *i.e.*, baggage and parcel, service, and a freight service on the electric road, separate cars for the purpose running every hour, the gross tonnage carried averaging 1,043 tons per month.

The tracks are laid with 80-lb. T-rails on cross ties, and are well ballasted. They occupy about two-thirds of the width of the public highway, and though the Company possesses no exclusive right to any portion of the highway, the mode of construction of the railway, and the elevation of the rails above the road practically deprive the public of the use of so much of the roadway as is required for the railway. Probably no great inconvenience is experienced on this account, as the highway is unmetalled, and is little used for vehicular traffic. The advantages conferred on the public by the railway more than balance any inconvenience due to its presence.

(2.) The Buffalo and Lockport Electric Railway is an overhead high speed single track trolley line 25½ miles in length, of which 12½ miles are within city limits. The motor cars are 42 ft. long over all, and are fitted with four 50-H.P. motors. There are also some 30-ton electric locomotives used for freight service, which haul ordinary freight cars, and which are equipped with four 160-H.P. motors.

The schedule speed for inter-urban running is 27 miles an hour, and the maximum is 50 miles an hour. The round trip fare from Buffalo to Lockport and back is 75 cents (3*s*.).

The line is operated by the International Traction Company of Buffalo, which also owns the electric railway between Buffalo and Niagara, etc. The current is derived from the Niagara Falls Power Company.

(3.) The Detroit and Port Huron Shore railway is a single track road with passing loops, having a total mileage, including lines within city limits and passing loops, of 110 miles. It is a trolley line laid, so far as I saw it, alongside the highway, and endeavours have here been made to interfere as little as possible with the use of the highway for its original purpose.

The power station is at New Baltimore, about 32 miles from Detroit, and the current is transmitted to a distance of 40 miles in one direction and 20 miles in another. The transmission current is 16,000 volts, and there are five sub-stations equipped with 200 K.W. converters from which the trolley current is supplied. Most of the cars are geared for a maximum speed of 45 miles an hour, some with two motor equipments and some with four. The freight cars have four motors. Fifty passenger cars and 25 freight cars are in service.

Detroit is now the centre of about 400 miles of inter-urban railway, and much valuable experience has been gained here in the operation of this class of line. As the various lines were originally the property of different companies a great variety of construction is to be found. Nearly all the lines are now under the control of the Detroit United Railway Company, who are engaged in establishing a uniform system of equipment and operation.

(4.) The Aurora, Elgin, and Chicago Railway is one of the most recent and most important undertakings of this class yet constructed. The total length of route is about 60 miles, the greater portion of which is double track. The line is built entirely upon the company's own land except at public road crossings, the width of land occupied being from 100 to 60 ft. It is laid throughout with 80-lb. steel rails in 60-ft. lengths, with 2640 ties to the mile. It is operated on the third rail system, the conductor rail weighing 100 lbs. per yard, and being of a special description of soft steel. The top of this third rail is $6\frac{3}{16}$ ins. above the top of the running rails, and it is placed 19½ ins. outside the track. The track is most substantially constructed so as to be suitable for very high speeds, the regular maximum speed being intended to be 65 miles an hour, while 80 to 100 miles an hour can, it is anticipated, be made with safety. Experiments with such speeds are to be made next spring, after the road bed has had time to become thoroughly consolidated. The power house is at Batavia at one end of the line, and there are six sub-stations. The transmission current is 26,000 volts 3-phase alternating, and is carried by aluminium stranded cables, on poles placed alongside the tracks, the same poles

also carrying the telephone wires. The traction current is 600 volts direct, and no direct current feeders are needed, as the third rail has sufficient carrying capacity to conduct all the current needed from the sub-stations to the trains in the different sections of the line.

The trains consist of one, two, or three cars. The one and two car trains have every axle motor-driven ; the three car trains have one car without motors. The cars are 47¼ ft. over all. Those carrying motors are of extra strength in the sub-frame, and have four 125-H.P. motors, the most powerful equipment ever put on a motor car, other than those used on elevated railways, where the motor cars act as locomotives to haul several trailers. The wheels are 36 ins. in diameter, and have Master Car Builders standard flanges and treads. The axles are 6½ ins. in diameter, being the largest yet used on an electric car. The trains are expected to attain a speed of 50 miles an hour in 25 seconds starting from rest, a performance never before attempted in electric railway practice.

In most cases the traffic on inter-urban lines is conducted by means of train orders given by telephone. The train despatcher has his office located in some convenient spot, and the telephones are placed in cabins or booths or in the sub-stations along the line. The train orders from the despatcher are received at the telephone cabins by the conductor or motor man, and are repeated back to the despatcher by the man receiving them, the other man standing by and hearing them repeated. The orders are all received verbally, and no record is kept of them. No car is permitted to leave a telephone station until such an order has been received and repeated. This method seems to be cumbrous and out of date. On single lines the use of the electric train staff or tablet would be simpler and quicker, and would, I believe, add largely to the safety of the traffic. The instruments should be of such a nature that they could be operated by the conductors.

By the courtesy of the Chief Engineer of the General Electric Company I have particulars of several more inter-urban railways similar to the above, but enough has been said to show what great developments are taking place in this respect in the United States. Such lines are becoming of increasing importance, population becomes more numerous in their vicinity, land values are enhanced, industrial enterprise is stimulated, and the convenience of the public is served by a frequent and cheap means of transportation not only for passengers, but also for freight. Farmers are said to appreciate the facilities thus afforded them for conveying their produce into the cities, and large quantities of milk are now daily carried into the markets by electric cars. Where steam railroads exist side by side with the electric lines, the competition between the two has been keen. Steam roads having seen a large share of their passenger business taken from them, have made a hard fight to retain the local freight business. But it would appear that the increased prosperity and activity in a district, which are promoted by the presence of an electric line, result in bringing more business to the steam lines. So that while the electric lines will probably carry the local traffic, passenger and freight, for short distances, they will act as feeders for the through business of the steam roads. In other words, there is a place for each, and their interests are best served by working in harmony.

The experience gained in America in regard to electric inter-urban railways should be of great value to those engaged in the construction of similar lines, under the name of "light railways" in this country. American engineers have discovered that "a modern first class electric railway should have a location that will admit of the most direct route with as few curves as possible, and be so laid out as to curves as to have them as easy as possible." It has been found not only desirable but "most economical to purchase private rights of way," to use heavy rails, large ties, and plenty of good ballast. Experience has proved that a substantial, well laid track is a "vital factor" in the economical operation of such a road, and a "large factor" in its earning capacity. The question of the best type of car for such railways is still receiving much attention in the States, and has not yet been finally decided, but it is found

that a heavy substantial vehicle is necessary, and that the wheels should have deep flanges, broad treads, and strong axles. In some instances, as for instance on the Schenectady-Albany line the depth of the flange is limited by the grooved rail over which the cars have to run within city limits, but where high speeds are aimed at, safety requires that the wheels and wheel flanges should be similar to those employed on fast steam roads.

In England the electrical inter-urban railways, which have been constructed under the Light Railways Act of 1896, differ in every respect from similar lines in America. They are almost invariably laid alongside the high roads, have light rails, and insufficient ballast, while the cars employed on them are mostly double-decked and have tramway wheels with small flanges. Such lines are nothing more than tramways, and quite unsuitable for high speeds. If railways of this nature are to be as successful here as they are in America, their owners must, I venture to think, profit by American experience, and follow American methods.

Descriptions of many other objects of interest will be found in my diary, and need not be repeated here.

In conclusion I have to express my grateful acknowledgments to my numerous American and Canadian friends, who did all in their power to make my visit to their country enjoyable and instructive. The President of the United States, to whom I paid my respects, gave me a friendly welcome, and all with whom I came in contact, without exception, spared neither time nor trouble to assist me in my enquiries, and to make me feel at home. Wherever I went I was cordially received, and invitations were tendered to me to extend my tour through the whole length and breadth of the country, of which, I hope, I may be able to take advantage on some future occasion.

I have the honour to be,

Sir,

Your obedient Servant,

H. A. YORKE,

Lt.-Col., R.E.

DIARY OF TRIP TO AMERICA.

September 19th to October 31st, 1902.

Friday, September 19th.—Sailed from Liverpool at 5 p.m. on board White Star S.S. "Celtic."

Sunday, September 28th.—Arrived at New York at 8.30 a.m. After passing baggage through the Customs, reached the Waldorf Astoria Hotel at 11 a.m.

Monday, September 29th.—I went to the Grand Central Station and called upon the officers of the New York Central and Hudson River Railroad. Spent the day inspecting the Central Station, the signalling and working of the traffic through the yard, and all the arrangements connected therewith. The signal cabin contains 147 levers in use, the points and signals being operated on the low pressure pneumatic system, installed by the Pneumatic Signal Company, of New York. The yard is very much congested, and the traffic operated under great difficulties. Many of the passenger trains are "fly-shunted" into the station, the engine taking one track, and the train being switched into another. The train travels into the station by its momentum, being controlled by the hand brakes, the air brake being held in reserve in case of emergency. The operation is risky, but has, hitherto, I was told, been unattended by any mishap. I also visited the office of the American Express Company, and saw the method of handling baggage and express freight.

Tuesday, September 30th.—At 9.30 a.m. I went by the Elevated railway to call on Mr. Westinghouse at his office at 120, Broadway. Mr. Westinghouse was not in the city, but I was received by Mr. Calvert Townley, who had been told by Mr. Westinghouse to look out for me, and assist me. I went with Mr. Townley to call upon and present my letters of introduction to Mr. E. P. Bryan. General Manager of the Rapid Transit Subway Construction Company, and Mr. W. B. Parsons, Engineer-in-Chief to the Rapid Transit Commission. Both gentlemen received me with much friendliness, and promised me every facility for seeing the Rapid Transit Subway at present under construction. Fixed the date and time for my visit to the subway works. The day was mostly occupied in making arrangements for my future movements.

Wednesday, October 1st.—Mr. J. N. Beckley met me at the hotel and arranged for a trip to Chicago and the West. At 10 a.m. I went to Mr. Westinghouse's office and found that gentleman there. He received me most cordially and arranged for me to go with him on Friday, 3rd inst., to Pittsburgh. I then went to call upon and present letter of introduction to Mr. A. Skitt, Vice-President of the Manhattan Railway Company, and obtained from him the necessary permission to visit the line, which is better known as the Elevated Railway of New York.

Thursday, October 2nd.—I met Mr. G. S. Rice, Assistant to the Chief Engineer of the Rapid Transit Commission, and accompanied him over a section of the new subway. The works are on a very large scale, the excavation being to a large extent through very hard rock, about 300,000 cubic feet of rock having to be removed out of a total of 3 million cubic yards. The length of the line is 21 miles (7 miles being four track and 14 miles double track), and the total estimate is 35 million dollars, out of which about 21 millions have been expended. An enormous number of drains, pipes, and conduits have had to

be diverted, and the street traffic has to be continued without interruption. The condition of some of the streets where the work is in progress is deplorable. The subway provides for four tracks, two for express trains, and two for local trains, and no portion of the work is yet open for traffic. The subway is rectangular in section, and is constructed wholly of steel uprights and girders, with concrete floor, walls, and roof. The concrete is of a high quality, the cement (of American manufacture) being exceptionally good. Every effort is being made to render the whole subway absolutely waterproof from end to end. In the afternoon I called on Mr. Vreeland, President, Metropolitan Street Railway Co., and afterwards went with Mr. M. G. Starrett, Chief Engineer of the Company, to see the power house of the street railways and to inspect a portion of the track. These street railways are worked at present partly by horse traction, partly by cable, and partly by electric power, but they are being converted throughout into electric lines on the "conduit system." The rails are of various descriptions and weights, and the track in many places is in a bad condition. It is, however, being gradually relaid, a grooved rail being now adopted as the standard, the groove being wider than is usual in England. The traffic on these tramways, or surface lines, is very great, the cars being always full, and at certain times of the day crowded. The fare is 5 cents for any distance. Tickets are not issued, but when necessary "transfers" are given by the car conductors at places where different routes intersect, so as to enable a passenger to change from one car to another without further payment. A check is kept upon the conductors by means of a registering machine in each car, which has to be operated by the conductor every time a fare is paid, and which thus records the number of fares paid. Both single truck (or four-wheeled) cars and double-truck (or bogie cars) are used upon these lines, there being altogether about 2,600 cars in use. The cars are fitted with a hand brake only and with a life guard of a type which is of little or no use. The schedule speed is eight miles an hour, including stops, but "down town" the speed is very much less than this.

The power station visited by me contains 88 B. and W. boilers arranged in three tiers and 11 engines of 5,000 H.P. each, of which six are running. The generators are 3,500 K. W. machines producing current at 6,600 volts (alternating), which is transformed in static transformers to 370 volts (alternating), and then converted in rotary converters into direct current at 575 volts. The chimney of the power station is the highest in New York, being 353 ft. high, with an internal diameter of 22 ft.

Friday, October 3rd.—I left New York at 7.40 a.m. with Mr. Westinghouse in his private car for Pittsburgh, travelling by the Pennsylvania Railroad *viâ* Philadelphia and Harrisburgh. Had a very pleasant and interesting journey by daylight over this fine railroad, which is the premier line in the States. The scenery in places is very attractive, especially in the Alleghany mountains and when passing round the celebrated Horse Shoe curve. The railroad consists of four tracks and is laid with heavy rails (flatbottomed as is usual in the States) and broken stone ballast. It is in fine order, and is apparently as good as the best type of English road. We arrived at Pittsburgh at 7 p.m. and went direct to Mr. Westinghouse's private residence at Holmwood. I should mention that the line from New York to Pittsburgh is signalled throughout on the automatic (electro-pneumatic) system, which is said by the railway officials to be entirely satisfactory.

Saturday, October 4th.—At 8.30 a.m. I visited the Union Switch and Signal Co.'s works (the company is one of the Westinghouse undertakings) and spent the whole morning with the general manager examining the details of the electro-pneumatic appliances for operating points and signals and for automatic signalling. There is a large gallery fitted up with a circular track and a complete installation of automatic signals. A model train actuated by electricity travels round the track and exemplifies the working of the signals, &c.

In the afternoon I visited the Pittsburgh railway station and signal cabin. The station, which is new, contains 16 tracks and is well provided with waiting rooms, &c. The waiting accommodation at important modern American

stations is very complete and far superior to anything to be found in England. In addition to large waiting halls, well warmed and fitted with ample seating accommodation, there are comfortable rooms for women containing all sorts of toilet requisites and conveniences, even cots for babies being provided; there are also smoking rooms for men, and barber's shops, besides baths and lavatories of a superior description. The restaurants are excellent and the kitchen arrangements are of the most modern type and supplied with every labour-saving appliance for cooking and washing up.

The station yard is laid out and signalled in the most approved fashion, the points and signals being operated by the electro-pneumatic system from the signal cabin, which contains 131 levers, of which 12 are spare. A cabin such as this contains about five or six men, viz., one to watch the traffic from the window and give directions to the men at the frame; one to attend to the telephones and receive from and send to the station staff information relative to the departure and arrival of trains; one to make entries in the train register of the movement of trains; and two or three at the frame itself. In England such a cabin would not contain more than two, or at the most, three men.

Movable crossings and spring frogs are used throughout the yard and are said to answer very well.

Sunday, October 5th.—I drove round Pittsburgh which is a very smoky place, the city being as black and grimy as London, but the scenery round the place is good.

Monday, October 6th.—At 8.30 a.m. I went to the Westinghouse Brake Company's works with Mr. Herman Westinghouse, who is the President of that Company. This, which was the first of Mr. George Westinghouse's undertakings, is still one of the most important, as it practically has the monopoly for supplying the whole of the American railways with brake gear. I examined the details of the "High Speed Brake" and the "Rapid Acting Brake," the former being a development of the latter. The High Speed Brake is as the name implies suitable only for heavy trains travelling at very high speeds. It requires a pressure of 110 lbs. of air when it is first applied, and is fitted with a reducing valve, which, as the speed of the train diminishes, gradually reduces the air pressure to the normal pressure of 75 lbs. The object of this device is as follows. If the pressure of 110 lbs. were applied to brake blocks acting on wheels revolving at moderate velocities, and carrying only moderate axle loads, it would cause the wheels to skid. On the other hand the normal pressure of 75 lbs. is not sufficient to produce an immediate effect upon wheels revolving at high speeds, and probably carrying heavy axle loads. The high pressure is therefore necessary for the high speeds, but if continued too long, *i.e.*, after the original speed has been diminished, it would cause the wheels to skid. For this reason the high pressure after its first application is automatically and gradually reduced to the normal pressure of 75 lbs. From time to time references to this appliance have appeared in the English papers, and our English railways have been urged to adopt it, and have been blamed for not doing so. But as a fact the responsible officers of the brake company do not consider that the High Speed Brake is necessary, or indeed suitable, for English conditions, because unless employed with the greatest care on English trains it would lead to the skidding of the wheels. Moreover, not many English Companies use the Westinghouse brake, the majority of them having the vacuum brake. The Rapid Acting Brake employs air at the normal pressure of 75 lbs., and the feature of it is the rapidity with which it acts upon every coach in a long train, so that the interval of time between the application of the blocks upon the front and rear wheels of a train, however long, is inappreciable. Its action is in fact instantaneous throughout a train, and a train can therefore by its means be stopped very quickly. Those English companies which use the Westinghouse brake might, with advantage, adopt the "Rapid Acting" type.

I also examined all the details of Newell's magnetic brake for tramways and street railways. The invention is that of a Mr. Newell, an engineer of Chicago, and the Westinghouse Company has bought up the rights. Much

time and care have been spent in perfecting the appliance before placing it on the market, but it is now being manufactured on a large scale. It is a slipper, or track, brake consisting of an electro-magnet, which is excited by current generated by the motors acting as "generators." The slipper, when thus magnetised, is strongly attracted to the rails, and acts as a very powerful brake. The slipper is also connected to brake blocks on the wheels by a system of levers in such a way that the drag on the slipper caused by its adhesion to the rails, presses the blocks against the wheels, so that the magnetic brake operates as a wheel brake as well as a track brake. Resistances are provided, which automatically regulate the current in the magnets, and these resistances are utilised in winter for heating the car. I believe this brake is one of much value for tramway purposes.

I was then shown the Westinghouse Friction draw gear, which has been designed to absorb the shocks produced on the draw bars by the starting or stopping the large freight cars, now in such general use on American railways. It is said to give good results, and is being largely adopted throughout the States, with the consequence that broken draw bars are less frequent.

Another ingenious device shown to me was an automatic coupler for automatically coupling the brake pipe, and (for passenger cars) the steam heating pipe as well. This coupler is an unsightly object, but may prove to be useful. At present the advantage of the automatic draw gear coupling between freight cars is partly neutralised by the necessity which exists for men to go between the cars for the purpose of coupling or uncoupling the brake pipe. It is, therefore, evident that if this latter operation can be performed automatically at the same time as the former, the risk of injury to the men will be still further reduced.

In the afternoon I went to the Westinghouse Electric Works. These are very extensive and are equipped in the most modern fashion. Here every description of electrical machinery is manufactured, such as generators, motors, transformers, converters, switch boards, controllers, &c. I saw some exceedingly large alternating generators being built, the external diameter of which was 42 ft., the diameter of the revolving armature being 32 ft. I examined the Westinghouse method of pneumatic control for multiple unit trains, which seems to possess the great advantage that no high voltage electric currents are introduced into the driver's compartment or carried through the train, the movement of the controller switches being effected by compressed air, supplied from a reservoir charged by means of a motor-compressor. The valves regulating the admission of the air to the controllers are operated by electro-magnets energised by low tension currents from a local battery, these currents being manipulated by the driver's handle. A very large shop, 1,200 ft. long, is devoted to the manufacture of motors for railways and tramways. The company are manufacturing eight large generators for the Manhattan Elevated Railway of New York and eight others for the New York Subway.

Tuesday, October 7th.—At 9 a.m. I started on an electric car, which the management kindly placed at my disposal, to examine the street railways, or tramways, of Pittsburgh, which are operated by the Pittsburgh Railways Company, a recently formed combination of several separate companies. The system comprises about 250 miles of track, equal to 125 miles of double line. The track is laid with a variety of sections of rail, but a "step" rail is now the standard. This rail has a depth of nine inches and a weight of 90 lbs. per yard. It is laid on cross ties or sleepers, the latter resting on ballast without any concrete. The old tracks are in a very indifferent state of repair, but the new track is good. The section of rail though not one suitable for English streets, and one which is being discarded in most American cities, appears to be popular in Pittsburgh because it affords a convenient track for heavy lorries or "teams," the gauge being 5 ft. 2½ ins. The gradients in many places are steep and the curves are sharp, the worst having radii of 50 ft. The speeds attained are high according to English ideas, especially when the congested state of the streets in Pittsburgh is considered, while outside the busiest portion of the city the cars travel at speeds of 25 to 30 miles an hour. The cars are mounted, some on 4-wheeled (single) trucks, and some on 8-wheeled (bogie) trucks.

The single truck which gives the most satisfaction here is the McGuire truck with 7 ft. 6 in. centres ; the bogie truck is the Bemis with four wheels of equal diameter, viz., 33 inches. The tread of the wheels is $2\frac{1}{4}$ ins. and the flange is $\frac{3}{4}$ in. wide and $\frac{3}{4}$ in. deep. Considering the speed at which the cars travel at outside the city limits the dimensions of the flanges are hardly sufficient. The single trucks have motors of 56 H.P. each, and the bogie cars have four motors of 45 H.P. each, or a total of 180 H.P. per car. The life of a wheel is about nine months, equal to about 35,000 miles of travel. The cars are all fitted with the Newell magnetic brake already described, which the superintendent of the cars regards as the most important and valuable modern invention for tramway purposes.

Many of the junctions are fitted with electric switches, an apparatus that I have never seen in England. These switches are operated from the car and are almost automatic. A section of the trolley wire is insulated from the rest and is fed independently. If the car on reaching this takes current, the current passes through a powerful electro-magnet, which by a system of levers pulls over the switch before the car reaches it. If the road is set (*i.e.*, if the switch is lying in the position) for the track the car has to take, the motor-man must shut off the current before he reaches the insulated section of the trolley wire, and pass across that section by means of the impetus already possessed by the car. The switch then will not be moved. If, however, the switch requires to be moved, to enable the car to take the turn out, the motor-man must not close his controller, but should allow current to flow as he passes over the insulated section. The magnet is thereby operated and the switch is pulled over before the car reaches it. This device seems convenient, as it saves delay and renders unnecessary the employment of men or boys for the purpose of shifting tramway switches, who are often exposed to danger in so doing.

In places where a double track joins a single track, and where the view is bad, the lines are fitted with automatic electric signals of a simple description, operated by the trolley, which inform the motor-man of a car whether the single line ahead is occupied by a car approaching from the opposite direction or not. This is a useful arrangement, and makes for safety.

During my trip over these tramways I was given the opportunity of visiting the Carnegie Steel Works at Homestead, which have recently been acquired by the American Steel Trust. The works are very extensive, and cover over two miles of the river bank. My visit was of necessity a hurried one, but I was shown by general manager some of the most modern plant for manufacturing steel. The works are turning out 5,000 tons of finished material, *i.e.*, steel girders, steel rails, plates, angles, joists, &c., daily. The process is mostly the Siemens-Martin basic method, and the metal is never allowed to cool from the time it leaves the smelting furnaces until it is in its finished form, whatever that may be. Natural gas is largely employed in the furnaces, being brought by the Company's own pipe line from a distance of over 100 miles. The machinery is all operated by electricity, and is so designed that the number of men required for the various processes is wonderfully small.

In the afternoon I went to the Westinghouse Machine Company's works, which form another of the enterprises initiated and controlled by Westinghouse. Here I saw some very large engines being built for electric power stations. The most interesting features were the turbine engines (Parsons), of which the Company has obtained the American rights. One of these engines, which I saw being tested, has 500 h.p. with 1,500 revolutions per minute ; and another has 1,000 h.p. with 3,600 revolutions per minute. The steam enters one end of the turbine at a pressure of 160 lbs., and passes out at the other end into the exhaust chamber, the vacuum in which is about 28 inches. Some very large turbines of 5,000 k.w. are being built here.

The construction of these turbines is very simple. They consist of solid wheels or discs of varying diameters, on the perimeters of which are fixed radially gun-metal blades or teeth, a few inches in length. These blades are curved in section, and are placed close together thus—(((((((. The discs revolve in a cylindrical case upon the inner surface of which are fixed similar blades in

a reverse position thus—)))))))). There are several rows of these blades in the case corresponding with the number of wheels or discs, and the blades on the latter revolve between the fixed blades on the case, the intervals between the two being as small as possible. The steam on being admitted into the end of the cylindrical case impinges against the concave surfaces of the fixed blades. and is thereby diverted so as to strike the hollows of the revolving blades ; it then passes to the next row of fixed blades, and is again diverted into the next row of revolving blades, and so on. By the impact of the steam upon the blades and by its reaction in leaving them, motion is communicated to the latter, which immediately commence to revolve at very high speed. In order that there may be no loss of steam, and therefore of power, the clearances between the revolving blades and the casing, and between them and the fixed blades, must be as small as possible. The power varies according to the diameter of the wheels or discs, the length of the blades, the pressure of steam, and the completeness of the vacuum. These turbines are said to be remarkably efficient under all conditions of loading. There can be no doubt about their simplicity ; they occupy little space ; and they have remarkably high speed. It is the opinion of many engineers in America that the turbine engine is the engine of the future, at least as far as the generation of electricity is concerned.

The Westinghouse-Parsons turbine is fixed on a horizontal shaft, and in this respect differs from another type of turbine, which is attached to a vertical shaft, and which will be described later on.

Another speciality of the Westinghouse Machine Company's works is the gas-engine, which they are taking great pains to develop, for driving generators. I saw some 300 h.p. and 500 h.p. gas-engines which were running with remarkable smoothness, and which gave no trouble whatever. The governing devices are now so perfect that the action of these engines is almost automatic, after they are once started.

After this I was taken to the manufactory lately started by Westinghouse for the production of the Nernst lamp. This is an incandescent lamp, the filament of which is incombustible, and requires no vacuum. It derives its name from that of its inventor, Dr. Nernst, a German scientist. The filament, or, as it is called, the "glower," is a non-conductor of electricity at normal temperatures, and the lamp is fitted with a "heater" to give the glower sufficient heat to make it conductive. As soon as this takes place the current traversing the glower causes it to emit a brilliant light, and also develops sufficient internal heat to keep it in the conductive condition, the heater being then automatically cut out of circuit. The Nernst lamp requires only about half the electrical energy needed by ordinary incandescent lamps for any given illumination. The glower has a life of 800 hours, and when used up can be easily renewed without affecting the other parts of the lamp. The lamp gives a soft light of a pleasanter character than that of the ordinary incandescent lamp. It is now being placed on the market in America, but owing to an agreement with the parent company in Germany, the Westinghouse Company is debarred from supplying the English or Continental markets with it, the latter having to depend upon Germany for their supply. This is unfortunate, as the Westinghouse type of Nernst lamp seems likely to prove a great success.

At 7 p.m. I left Pittsburgh with Mr. Westinghouse and party in his private car for New York. We dined and slept on the car, which is a very fine one, being 78 ft. long, with sleeping accommodation for eight persons, two lavatories, dining room, smoking room, kitchen, &c.

Wednesday, October 8th.—We arrived in New York at 10.30 a.m. after a very comfortable journey. When nearing New York the train was switched across from the east-bound track, *i.e.*, the one we were on, to the west-bound, or, as we should say in England, the "facing" track. Why this was done I could not ascertain, as there seemed to be no obstacle on the right track. But, whatever the reason, we ran without any halt or pilotman at high speed on the wrong track, there being of course no signals for our train. It seems to be a regular practice in America to do this, when for any reason it is thought convenient—a system which according to English ideas is most undesirable

and dangerous. American railway practice in such matters may be more elastic than English, but it is not so safe ; but in America they take "more chances."

In the afternoon I visited the office of Westinghouse, Church, Kerr & Co., which is an engineering concern instituted by Mr. Westinghouse for the purpose of initiating, designing, and executing large works of all sorts. They do not act as consulting engineers, but as engineering contractors. They are prepared to make the whole of the plans and estimates, to work out all the engineering problems connected with any scheme however large, to make all the calculations, and to carry out the work on a percentage basis. They work in concert with the other Westinghouse companies, but form an independent undertaking. Their offices are very large, their organisation very complete, and they have a brilliant staff of engineers in their employ.

I was shown by Mr. Kerr the designs for the new tunnels about to be constructed for the Pennsylvania Railroad Co., under New York Harbour, for the purpose of giving that railroad access into New York City. At present this railway has its terminus in New Jersey City, and all passengers and freight for New York have to be ferried across the harbour to quays in New York. Sometimes whole trains are placed on barges and ferried over, the barges or "flats" having on their decks three railway tracks each capable of holding several cars. But for the bulk of the passengers ordinary ferry boats are provided, which meet every train, and pass backwards and forwards all day. At present there is no communication except by water between New Jersey and New York, and as several railways from the west and south have their termini in New Jersey a good deal of delay and inconvenience is caused to passengers. The Pennsylvania Co. now intend to rectify this. They have, with the assistance of Westinghouse, Church, Kerr, & Co., got out a big scheme for driving two tunnels or tubes under the harbour, or North river, into a large underground station in the heart of New York. From this station four tunnels will be driven under the East river into Brooklyn and Long Island, where a large marshalling yard and depôt will be laid out. The lines will then come to the surface and will be connected with the Long Island Railway, which has already been acquired by the Pennsylvania. On the west side the lines will join the existing main track of the Pennsylvania Company about five miles from their present terminus in New Jersey, so that direct communication into the heart of New York, and, if needed, into Long Island, will be available. The tunnels are to be cylindrical in section with a diameter of 19 ft. 6 ins., and the traffic through them will be worked by electric locomotives. Four "blocks" have been acquired for the site of station in New York, which is to be on a very large scale. The lines and station in the city will be entirely in tunnel, which will be several miles long, and which, it is expected, will be driven almost entirely through rock. Altogether this is the biggest scheme of the sort ever contemplated, and is estimated to cost 50 million dollars. The firm of Westinghouse, Church, Kerr, and Company have had the designing and execution of this work entrusted to them, a joint committee having been formed, comprising officers of the railway company, members of the firm, and members of the Rapid Transit Commission, to settle the details. It is expected that the work will be commenced shortly.

Thursday, October 9th.—I started at 9.30 a.m. from the Grand Central Station to inspect the track, &c., of the New York Central Railroad. Mr. Wilgus, the Chief Engineer, kindly went with me, together with other officers of the Company. We travelled in Mr. Wilgus's car, the engine attached to which has an inspection coach on the top of the boiler between the "cab" and the chimney, forming a very convenient, though rather warm, place from which to view the track, signals, &c. We ran about 70 miles from New York and back at a speed of 50 to 60 miles an hour. The scenery on this section of the line is very beautiful. I was struck by the smoothness of the track and the absence of noise and vibration, which may be due to the mode of construction adopted in America, namely, the flat-bottomed or Vignoles rail resting directly upon the sleepers or "ties" without the intervention of chairs. The standard rail now in use on the New York Central Railway is of the Vignoles section, weighing 100 lbs. per yard, with a head 3 ins. wide, a flange 6 ins. wide, and a web 6 ins. deep, and this in use between Albany and New

York. The rail rests upon ties 2 ft. 2 ins. apart, to which it is secured by spikes, no screw fastenings of any sort being employed. The line is admirably ballasted with broken stone, and is in all respects (except perhaps as regards the spikes, which I regard as weak fastenings) in best possible condition. The essential difference between this and the English type of permanent way, lies in the absence of chairs. So far as I understand the matter, the advantage of chairs is that they afford a much larger bearing area between the rail and the tie, and prevent the former from cutting into the latter. In America the same object is partly obtained by using more ties than in England, but as English companies are now increasing the number of sleepers the difference in this respect between the two systems is not so great as it was. The Americans are finding out that with their modern heavy engines the bearing of the rails on the sleepers is not sufficient, for they are using bearing plates, between the rails and the ties to increase this area, and to enable the spikes to give mutual support to each other. They are also making much use of "braces," or side supports, for the rails, especially on curves. And when these additions have been made they have made a considerable approach towards a chair road. I venture to think that the weak point about the American road is in the spikes, and I believe that if they would use screw fastenings between the rails and the ties their road would be vastly improved. The rail formerly used by New York Central Railway weighed 80 lbs. per yard, and though the line is being relaid with the 100-lb. rail, it will be some years before the 80-lb. rail has disappeared. The rails are all 33 ft. long, and the joints are not opposite to each other as is usual in England. The joints are usually "supported" instead of "suspended" as in England. The curves as a rule do not exceed 955 ft. in radius (6 degrees), but there is one curve near Albany with a radius of 700 ft. This company makes large use of "spring frogs" and also of "movable frogs," of both of which appliances the engineers spoke well. As regards spring frogs, opinion in America is by no means unanimous; but as regards movable frogs, which are operated from a signal cabin, and interlocked with the signals and fitted with locks and lock-bars, they seem to give general satisfaction. These appliances are practically unknown in England, but the London and South-Western Railway have recently introduced a few sets for experiment.

The signalling of this section of the New York Central Railway is on "controlled manual" or Syke's system; but automatic signals are to be installed shortly. The distant signals have at present a yellow arm, and at night show a green light when in the "danger" position, and white light for "all right." The home signals are painted red and at night shew a red light for "danger," and a white light for "all right." The signals are operated by double wires, that is to say, there is a wire to place them at danger as well as to pull them "off."

On my return to New York I was taken round the harbour by the engineer of the New York Central Railway in the company's steam launch. The feature that strikes one most is the immense activity apparent on all sides. Vessels of all descriptions are always on the move. There are the public ferry boats, and the railway ferry boats, and the railway barges with whole trains of freight cars on their decks, crossing the harbour from one side to the other. And there are coastwise steamers and ocean going steamers steaming up and down the central channel: and there are yachts, and launches darting hither and thither, and seeming to invite constant risk of being run down; the busy appearance being more marked than anything one sees on the Thames or Mersey. Another feature that attracts attention, is the manner in which every yard of river front is occupied with docks. These are not docks such as are known in England, but rather a succession of bays arranged at right angles to the shore, with dividing piers or quays between them, each of which has a conspicuous number above it. These bays are long enough to take the longest ocean going steamers, which enter them stem first, and come to rest with their bows against the shore and their broadsides along the piers. There are no gates, and no large enclosed sheets of water, these being quite unnecessary owing to the fact that the rise and fall of tide does not exceed 5 ft. and vessels can enter and leave the docks at all times irrespective of the tide. These bays extend on both sides of Manhattan Island, on which New York City is situate, and also

on the sea fronts of Jersey City, and of Brooklyn. The accommodation thus afforded is enormous, and the harbour has capabilities such as few, if any, other places possess. I steamed all round the harbour both in the North River and the East River. I also visited the Navy Yard, which is situated in Brooklyn and saw some of the United States war vessels, most of them being cruisers equipped for the Spanish-American war.

To revert for a moment to the New York Central Railway I should mention that the company intend to introduce electric traction on their main lines for a distance of 35 miles out of New York. This is being forced upon them in consequence of the disastrous collision that occurred in the tunnel under the city which occurred in January last. There are four tracks through the tunnel which are daily used by a large number of trains belonging to the different companies using the Grand Central Station. So that the tunnel is constantly filled with smoke and steam, its condition having for a long time past been a cause of much complaint.

The company are encouraging their staff to take a pride in appearance of the track and stations and give yearly prizes for the best kept sections and stations, some of latter in the neighbourhood of New York being very neat and attractive. Not only are gardens a common feature, but well trimmed lawns alongside the tracks are frequently met with. The company is also following the example of English companies in the introduction of water troughs to enable engines to take up a supply of water while running.

Friday, October 10th.—At 10 a.m. I went from New York to Boston with Mr. C. Townley. We arrived at Boston at 3 p.m., and I at once called on General Bancroft and Mr. C. S. Sergeant, president and vice-president respectively of the Boston Elevated Railway Company. This Company operates the surface lines (or tram lines) as well as the Elevated railway, the two together forming a very extensive system, extending on all sides to the neighbouring towns. The problem of locomotion through the City of Boston became urgent about the year 1891, and a Commission was appointed by the Legislature of Massachusetts to investigate and consider the subject of rapid transit in the City.

In 1892 the Commission reported to the Legislature, and recommended that a tunnel or subway should be built under Boston Common and Tremont Street, where the traffic was most congested, for the use of the tramways, and that two elevated railways through the city should be constructed. The work was commenced in 1895 and completed in 1898. The Elevated Railway Company, which acquired by purchase or lease the control of the surface lines as well of the elevated, pays a rent for the use of the subway, and the system of communication both in the city itself and in the surrounding townships is more complete in Boston than in any other city I visited. The subway contains five miles of track; the Elevated railway consists of 16 miles of track, and the Surface lines of 385 miles of track, in all cases measured as single line. The subway was originally designed for tramcars only, and it was at a later date that it was decided to devote two of the tracks in it (in places where there are four tracks) to the use of the trains from the Elevated railway. In this way it has come about that there are in it many curves and gradients, which though not unsuitable for tramcars are a serious obstacle to the Elevated trains, the service upon which suffers accordingly. I spent some time on Friday evening watching the traffic passing through Park Street Station on the subway. This is one of the busiest places on the subway, and in the evening the number of passengers is great. There are four tracks through the station, two for the tram lines and two for the elevated trains. The tram lines are in the middle and terminate here in a loop, the tracks used by the elevated trains being outside the others, and separated by a sufficient space to make room for the loop. The tramcars from all the routes pass through this place in an endless succession, each car being conspicuously marked to indicate its route. The crowd is so great at the busy hour that a special force of inspectors is employed to prevent people from boarding the cars while they are in motion. The tramcars run singly, but the trains of the Elevated railway consist of four cars.

Saturday, October 11th.—I spent the morning on the Elevated railway, and the afternoon on the Surface or tram lines.

The Elevated railway, which is $6\frac{1}{2}$ miles long, comprises about 16 miles of track including sidings, laid with 85-lb. rails, the third rail (or conductor rail) weighing 100 lb. per yard. As its name implies, the Elevated line for the most part is carried on a steel viaduct along the streets, but, as already stated, in places it passes into and through the subway. The whole of the steel structure is bonded and connected with the power station so as to assist in acting as a return conductor. On the whole it is a more substantial structure than the elevated line in New York, advantage having been taken of the experience gained in the latter city. Where, as often happens, the street tramways pass below the elevated line, the trolley wires of the former are attached to the underside of the viaduct, being at the same time doubly insulated therefrom. There are 120 cars on the elevated railway, and the trains consist of three or four cars. Each car has two bogie trucks, on one of which are placed two motors of 150 H.P. each, making a total H.P. on each car of 300, there being a controller at each end of each car. The trains are fitted with the Westinghouse automatic air brake, the air for which is supplied by an electric air compressor on each car. The controllers are of the Sprague multiple unit pattern, the handles of which fly back to the "off" position if let go. This ensures that if anything happens to the motor-man the trains shall come to rest. The current is supplied from the power stations, of which there are seven for the whole system, elevated as well as surface, at 550 volts (direct). The cars have each four "shoes" or "slippers" for collecting the current from the third rail, the latter being placed outside the rails in the space between the tracks. The wheels have $4\frac{1}{4}$ in. treads and flanges $1\frac{1}{4}$ in. deep.

The line is signalled throughout on the electro-pneumatic automatic system, the insulated joints between the sections being placed in each case 200 ft. beyond the signals marking the entrance to the sections. Alongside of the signals and working in conjunction with them are placed automatic triggers which apply the brakes should a train overrun a danger signal. This installation of automatic signalling is unusually interesting, as it is the first instance of this system being introduced on an electric railway using the rails (or one of them) for the return of the propulsion current. Track circuits for signalling purposes require the exclusive use electrically of at least one rail of each track to which the signals refer. Under ordinary conditions it is not found feasible to surrender one of the rails for this purpose. But on the Boston Elevated Railway, owing to the great capacity of the elevated structure as a return conductor, it was found possible to devote one rail entirely to block signalling purposes, the other rail being common to both the block and the propulsion circuits. Special means were devised to prevent the operation of the signals, or the damage of their controlling mechanism, in case the propulsion current should find a return through the block rail and instruments, and polarised relays had to be used so as to respond to currents in one direction only. The problem seems to have been cleverly solved on this line. The electrical energy for the block system is supplied by four motor generators placed in convenient places, driven by current drawn from the main propulsion feeders, and delivering current at 90 volts, which by means of resistances is reduced to 15 volts in the track circuit The air for operating the signals is supplied from air compressors fixed at the terminal station, these also being driven by energy drawn from the main feeders.

A very completely equipped school is provided for the instruction of the motor-men in all the details of the controllers and brake equipment, and the men have to pass a strict examination, and are also tested for eyesight and colour blindness, before being allowed to take charge of a train. The training of motor-men for Surface lines and all electrically operated railways appear to be more thorough in America than it is in England.

Sullivan Square Station, where the elevated trains and surface cars meet and exchange traffic, is a very interesting place and is admirably planned. This is a terminal station for the Elevated trains, which here run round a single line loop, one side of which forms a single track through the middle of the station while the other makes a circuit outside. The surface cars run into the station

on either side of the centre line, there being altogether 10 tracks (five on each side) devoted to them. These tracks form dead end bays, or as they are called in America " stub tracks." The elevated trains run at two minutes' interval, which is found to be the shortest that can be obtained with the signals arranged as at present, but it is contemplated to fix the signals nearer together so as to enable a still more frequent service to be obtained.

At junctions and places where there are switches to be operated, electro-pneumatic interlocking plants have been erected.

A good deal of trouble is caused by the sharpness of the curves on the subway section of the elevated railway. These curves not only affect the speed but have a very injurious action upon the wheels, upon which a series of ridges is soon formed, owing to the slipping of the wheels round the curves. The wheels have at very short intervals of time to be taken into the repairing shop, where instead of being turned in a lathe they are ground true by means of a grindstone. This is found to be quicker than turning them.

At Dudley Street Station on the Elevated railway the surface cars again exchange traffic with the elevated trains. This is a terminus for both elevated trains and Surface cars, all of which run round single line loops instead of into stub tracks. In fact, loops form a marked feature of most electric railways in America, as they do on the Metropolitan Railway of Paris, as I pointed out in my report last year.

In the afternoon I travelled over a section of the surface lines or tramways. These are at present laid with a variety of rails, but the grooved rail, with a wider groove than is usual in England, is now adopted as the standard. It weighs 80 lbs per yard. Where the vehicular traffic is heavy, especially where heavy lorries, or " teams " as they are called, are numerous, the " step " rail or tram rail is used. Outside the city the lines are laid on the grass alongside the roadway, and here an ordinary T railway rail is employed, which is laid with its upper surface level with the grass, the latter being brought close up to the rails on all sides, both between the rails and between the tracks. The Surface lines are practically double throughout, this being a feature of most American tramway lines, single lines not being approved.

The cars on these tramways are chiefly bogie cars, and a few of them have maximum traction trucks, which, however, are found here, as elsewhere, to be unsatisfactory. Some cars are four-wheeled, but these are said to be hard on the track, and are not liked by the management. All the cars have two motors, those on the bogie cars being of 40 H.P. each, and those on the small four-wheeled cars being of 30 or 37 H.P. each. The cars are all fitted with the ordinary hand brake, but no emergency brake. They have life guards or fenders of three different patterns, none of which can be regarded as satisfactory.

The tracks are laid on cross ties at about $2\frac{1}{2}$ ft. centres, and concrete is placed between the ties, but not underneath them. This is a very usual mode of construction in America, but I cannot help thinking that the concrete is in the wrong place, and that it would be better below the ties, or at any rate below the rails as is the custom in England. Heavy iron gauge rods are used to keep the track to gauge.

The speeds in the city streets is low, not exceeding six or eight miles an hour, but outside the town the cars are run at a speed of 20 to 25 miles an hour. The motor-men are well trained and handle their cars with care and skill.

The Company have to run some postal cars for the collection and distribution of letters under contract with the Post Office.

The overhead trolley system of traction is made use of, the current being supplied from seven power houses, the voltage being 550. The same power houses supply also the elevated lines. As already stated, the tram lines pass into the subway at certain spots and use the same stations as the elevated trains. As a general rule the termini of the tram lines are formed by means of single line loops and not with cross-over roads.

Sunday, October 12th.—I spent the morning examining the Boston South Station belonging to the Boston Terminal Company, which is an association of the five companies which run into it, viz., the New York, New Haven, and Hudson River Railroad Company, the Boston and Albany Railroad Company, the New England Railroad Company, the Boston and Providence Railroad Corporation, and the Old Colony Railroad Company.

This station is a remarkable structure, its most attractive features being the waiting halls, toilet rooms, and restaurant. The main car shed covers an area of 506,430 square feet, and the whole of the building is built on piles over which a concrete foundation has been placed. The roof of the car shed is ugly, being of a flat arched shape with a covering of tarred felt or paper. The result is that the interior of the shed is dark, except when lighted artificially. Steam pipes have been laid along all the valleys or gutters of the roof, for the purpose of thawing the snow and preventing any accumulation of it. The arrangements for heating and lighting are very complete, and the kitchen and feeding arrangements are admirable and far beyond anything that exists in England at any station.

I attach a printed statement giving a number of statistics concerning this station, about which a great deal has from time to time been said by English visitors. From this it will be seen that the greatest number of trains in both directions which use this place daily is 801, and the number of passengers per annum is 25 millions, or 68,500 per diem.

Comparing this with Liverpool Street Station in London, where the daily trains number 1,060, and the daily passengers on very busy days reach the large total of 179,680, it will be seen that, in spite of all that has been said, the operations at Boston are not so large as those here. And this fact becomes the more notable when it is remembered that at Liverpool Street there are only 18 platform lines as against 28 at Boston, and only six tracks leading into the former as against eight at the latter. Again, at Cannon Street Station, where there are nine platform lines and one middle road, with eight lines leading to and from them, the number of trains dealt with daily is 920, and at Charing Cross, with six platform lines and four tracks in and out, the number of trains handled is 550 daily.

The station yard at Boston is very well laid out, and the permanent way is good. Moveable frogs and spring frogs are largely used ; and here as elsewhere the former are well spoken of, but the verdict in regard to spring frogs is not so unanimous, some engineers approving of them and others disliking them.

The signalling throughout the yard is on the electro-pneumatic system, all the switches and signals being worked by power from three signal boxes, which contain 165 levers. About half a mile outside the station there is a bascule opening bridge of the rolling type. This bridge has two spans each of which weighs 500 tons, five-eighths of which is counterweight. The bridge is opened and closed by electric power, but owing to the skilful way in which it is balanced by the counterweights the electric energy required to operate the bridge is exceedingly small, the cost of each operation of opening and closing being only 2 cents. This type of opening bridge is very common in the States, there being several in Chicago and elsewhere.

Below the main station there is a subway to accommodate local trains. In this there are two loop single line tracks, so that the local trains can run through the station, and all shunting or shifting of the engine from one end of a train to the other is avoided. There are four tracks through the yard for these local trains. The subway is not yet in actual use.

In the afternoon I visited the public library in Boston, which is a fine building and admirably appointed. The facilities afforded to the public by these free libraries is remarkable, even children having large rooms set apart for them in which suitable books are provided. I then went to Hartford, and after dinner I was taken to see the power house of the Hartford Electric Lighting and Power Company. The chief source of power utilised by this Company is water, two water turbines having been erected 10 miles away, viz., one of 2,000 H.P.

and one of 1,600 H.P., the current there generated being 10,000 volts alternating. This is conveyed to Hartford on overhead conductors; it is then transformed to 2,400 volts, at which voltage it is distributed to several works, but for use in the centre of the city it is still further reduced, and is supplied at 220 volts direct. The most interesting feature was the steam turbine, which has been erected in the power house to supplement the water power, should that fail. The steam turbine was adopted because of its lower first cost as compared with a reciprocating engine; its smaller cost of installation; its relatively high efficiency at fractional loads; and the small space occupied by it. It was supplied by the Westinghouse Electric and Manufacturing Company, and has a rated capacity of 2,000 kilowatts, which can be increased by superheating. The steam is supplied by three Aultman-Taylor water tube boilers, each having a rated capacity of 500 H.P., which however can be increased by superheating.

This turbine has given entire satisfaction, and though it is not often called upon to supply energy, it is kept always ready in case of emergency and for use when the load is excessive.

Monday, October 13th.—I left Hartford at 8.33 a.m. and reached New York at noon. In the afternoon I met Mr. Potter of the General Electric Company, and Colonel Heft, electrical engineer of the New Haven and Hartford Railway Company.

Tuesday, October 14th.—I went over to Brooklyn at 10 a.m., and called upon Mr. Calderwood, assistant to the president of Brooklyn Rapid Transit Company. I then visited the surface lines of that Company. These lines are a consolidation of the lines of six formerly existing companies, five of which possessed surface lines, and one an elevated railway, in Brooklyn. The total mileage now owned or leased by the Brooklyn Rapid Transit Company is about 250 miles of double track, of which 28 miles form the elevated railroad. A new power-house is being built containing 32 boilers on two floors, each boiler having a capacity of 600 H.P., and eight engines of 4,500 H.P. each. There are two direct current generators (550 volts) of about 4,000 H.P. each, and six alternating current generators (6,660 volts) also of 4,000 H.P. each. The surface lines are worked on the overhead trolley system, and the elevated railroad on the third rail system, the voltage in both cases being 550.

The surface lines are now being laid with grooved rails in 60 feet lengths, which have been adopted as the standard, the groove being a wide one, and so shaped as to be self cleaning. Outside the city limits the surface cars run upon the same rails as the elevated trains, the speed attained being as high as 25 miles an hour. Inside the city speed restrictions are imposed of 8, 10, and 15 miles an hour. The cars, as is the universal custom in America, are "single decked."

The rails are laid on cross "ties" or sleepers, concrete being filled in between the ties, as is the case in Boston and New York and elsewhere. Although, as already stated, I do not think this is a good way of using the concrete, it undoubtedly makes a quiet and elastic road, but it is most difficult to maintain and does not afford such a good surface to the street. The condition of the streets is, however, not regarded in America as so important as it is in English towns.

The elevated railway is similar to that in Boston, already described, and to that of New York, which will be described hereafter. The third or conductor rail is laid outside the track rails, and the current is collected by shoes or slippers, of which there are four on each motor car. The trains consist of five cars, viz., three motor cars and two ordinary cars. The motor cars are fitted with the Westinghouse pneumatic multiple controllers. The motor cars have two motors of 150 H.P. each, on the same truck, the wheels carrying the motors being 33 inches in diameter and the other wheels 30 inches.

Both the surface cars and the elevated trains travel over the Brooklyn bridge into New York, separate tracks being provided for them respectively, the elevated tracks being in the centre of the bridge and the tramway tracks one on one side of the bridge and the other on the other side. The bridge is not

regarded as sufficiently strong to allow the surface cars to follow each other close together, and an interval of 100 feet has to be maintained between them.

I was disappointed with the Brooklyn Bridge, of which I had heard and read so much. It is constructed of steel wire ropes, there being eight such ropes in each of the four main cables. The slings supporting the floor girders consist of similar ropes, one rope to each sling, and these are attached to the main cables by iron straps or clips. One of these clips failed a short time ago and created a good deal of alarm, and it was in consequence of this that the regulation was made as to the distance of 100 feet being maintained between the tram cars passing over it. The total length of the bridge is 5,989 feet, of which the central or river span is 1,595 feet. It is interesting to compare this with the Forth bridge, the two main spans of which have each a length of 1,700 feet. The Brooklyn bridge does not give one an idea of great strength, and is not such an imposing structure as I was led to expect.

The elevated railway of Brooklyn terminates at the New York end of the bridge in a station raised above the street level. The surface lines after passing over the bridge descend to the street and spread out into four tracks, which circle round the end of the bridge, forming four single line loops.

The congestion of traffic here at the busy times of the day, morning and evening, is great, and forms one of the sights of New York. Many schemes have been proposed to remedy this state of affairs, but no solution of the difficulty has yet been found. The problem is worse now than ever, since the number of cars allowed upon the bridge at one time is limited.

Wednesday, October 15th.—At 9 a.m. I met Mr. Potter, chief engineer of the Railway Branch of the General Electric Company, and went with him over the Manhattan, or New York, Elevated railway, which is now in process of being prepared for electric traction by the General Electric Company. This line has hitherto been worked by steam, but many of the trains are already being operated by electricity, both steam and electric trains using the same rails. The line is supported on steel colums and girders, the level of the rails being about that of the first floors of the adjacent houses. The permanent way has no continuous flooring, the space between the ties being open. This has been done in order not to shut out the light from the street below, but it is presumed that some inconvenience must have been caused by ashes or water dropping from the steam engines into the street.

The length of the Manhattan Elevated railway is 55 miles of double track, and the number of cars in service is 1,089, equal to about 230 trains. The trains as a rule consist of five cars, when drawn by steam locomotive, and six cars when electrically propelled. The minimum interval between trains is 57 seconds, but the average interval is much more than this. The average speed attained by the steam trains is said to be from 13 to 14 miles per hour, including stops, but as the latter are very numerous, the distance between stations being about 575 yards, the actual speed between stations must be much higher. The above figures relate to the stopping trains, but there are four tracks on some of the routes, two of which are reserved for express traffic, and on these the schedule speed rises to 26·4 miles per hour. With electric traction higher speeds than the above are expected. The trains in the busy time of the day, viz., between 5 and 6 p.m., are densely crowded and very uncomfortable, it being almost impossible to get a seat, and difficult to force one's way into or out of a car owing to the crowd of passengers standing in the centre passage and end gangways. The platforms "down town" are thronged with people waiting for the trains, and railings are fixed to prevent persons from being forced on to the line, gaps being left in the railings opposite the gangways between the cars. Marks are placed in the six-foot way to guide the motormen in stopping the trains in the right place, so that the gangways may be opposite to the gaps in the railings.

The electric trains are divisible into two units of three coaches each, and during the middle of the day the trains are so split up. Each unit has two motor cars, viz., one at each end with an ordinary car in the middle. In this way the full sized train of six cars has four motor cars, two in the middle and

one at each end. Each motor car has two motors of 125-H.P. each, both motors being on the same bogie truck. The wheels carrying the motors are 33 inches in diameter, the others 39 inches.

The sharpest curves on the Manhattan railway have radii of 90 feet and the steepest gradient has an inclination of 2 per cent. or 1 in 50. These curves are a drawback, and where they occur speed has to be reduced to eight miles an hour and even less, partly on account of the risk of derailment, and partly because the motorman cannot see round the curves, and does not therefore know whether the line ahead is clear.

The line is not signalled, except at the curves, and the motormen regulate their movement in accordance with that of the train ahead of them. The service is in fact worked in the same way as that of a tramway. At the curves automatic mechanical signals are provided, which indicate to a driver of any train whether the previous train has cleared the curve or not. These are operated by treadles alongside the track. Flag men are also stationed at some of the worst curves. At switches and crossings, where such exist, ground signals are provided, which are interlocked with the switches and are operated from small ground frames.

The absence of block signals has hitherto been found to introduce no risks, the speed of the steam-driven trains being low. But with the introduction of electric traction, with its high speeds and higher rate of acceleration, viz., two feet per second per second, it seems probable that signals will be required, though at present it is not intended to provide them. Without them accidents will almost certainly occur.

The tracks are everywhere provided with inside check rails and outside timber wheel guards. The whole structure is bonded electrically and connected with the rails, which form the negative conductor.

The trains are fitted with the Westinghouse automatic air brake, air being supplied from compressors on each car driven by small auxiliary motors.

The controllers are of the General Electric Company's pattern, which enables any number of units to be controlled from any car. The controller magnets are placed underneath the car, asbestos sheets being attached to the underside of the car above the magnets. If the motorman lets go of the controller handle the current is at once cut off, and cannot be restored until the controller handle has been moved to the "off" position and then moved forward again. The removal of the reversing handle locks the controller handle, so that all the motorman has to do when he leaves his compartment is to remove the reversing handle and the controller is then out of use. This enables the space occupied by the motorman to be used by passengers when not required for driving.

The cars are mostly the old ones, formerly used in the steam trains, and which have been equipped for electric traction, for which, however, they do not seem well suited.

The track is laid with 80-lb. steel rails, and the conductor rail is of the same weight and section. The latter is placed outside the running rails in the six-foot way. The main transmission and feeder cables, from the power house to the substations and from the latter to the line, are also carried on the top of the girders of the railway in the six-foot way, an arrangement which is open to much objection, as, if an accident occurred such as the derailment of a train, and a short circuit were thereby caused, the results would be very serious and probably disastrous. But in such matters Americans seem prepared to "take chances" which would not be thought of in England.

The power house of the Manhattan railway contains eight alternating generators of 5,000 kilowatts each, there being two compound condensing engines to each generator, steam being supplied from 64 Babcock and Wilcocks' boilers arranged on two floors. The current in the first instance is 11,000 volts (alternating), which is transformed down in the substations to 390 volts, and afterwards converted by rotary converters into direct current at 600 volts. The

power house has four chimney stacks 280 feet high. Roney mechanical stokers are used, whereby only one third of the staff, which would otherwise be required in the boiler room, is needed.

The operation of preparing the line for electric traction while the trains are still running is highly dangerous to the men employed, the intervals between trains being so small, and there being little or no space in which the men can take refuge. I saw one unfortunate man run down and killed by an electric train a short distance ahead of the train in which I was travelling.

In the afternoon I had a very interesting trip to the mouth of the harbour on board a steamer with "Curtis" steam turbines to drive her. The great feature of these turbines was the extremely small space occupied by them, and their smoothness of running and absence of vibration were also remarkable. The steamer had twin screws driven by two turbines, each of 1,250 H.P., and the engine room was about ten feet square. The Curtis turbine is similar in principle to the Parson's, but differs somewhat in detail. It has a reversing turbine fitted on the same shaft as the forward driving turbines, but enclosed in a separate steam chamber. When the engine is in forward gear the reversing turbine is running free, no steam being admitted to it. But when the engine is reversed the forward turbines run free, while steam is admitted to the reversing turbine. The operation is instantaneous in action and very simple. Owing to the speed of revolution being exceedingly high a special form of screw is necessary, otherwise a vacuum is produced by the screw which impedes the forward movement of the ship. A thoroughly satisfactory form of screw has not yet been discovered.

Thursday, October 16th.—At 7.30 a.m. I went to Philadelphia, arriving there about 11. I spent the morning in Baldwin's locomotive works, where they turn out 2,000 locomotives a year, or more than 6 per day, the greater number of which are for use in the States. The thing that struck me most here was the extraordinary congestion of the works, which are so filled with machinery, material, parts of engines, and engines in process of construction, that it was hardly possible to walk through the shops. It seemed to me that the men worked under much disadvantage in so crowded a place. A number of books were given to me explaining all the features of the Baldwin engines, and all the specialities for which the works are famous. The works are situated in the heart of the city, and though they cover a large area it appears that their size is insufficient for the amount of work turned out. This concern is remarkable in America in that it has not been converted into a big public company. It still remains in private hands.

I lunched with Mr. Cassatt, the president of the Pennsylvania railroad, Mr. Rea, vice-president, Mr. Pugh, another vice-president, and several of the chief officers of the line being also present. Mr. Cassatt is regarded as the most powerful railway man in America. I then heard a good deal about the scheme already alluded to for tunneling under the harbour at New York so as to give the railroad access to that City.

Mr. Richards, engineer of the Philadelphia Division of the line, and the signalling superintendent gave me all the information in their power on their practice in track work and signalling.

The permanent way is similar to that already described as adopted on the New York Central railway. It is in fine condition and admirably maintained, and as neat as care and attention can make it. Mr. Richards said that he had tried a mile or so of line constructed according to London and North Western method, and did not like it. But I do not think that he has tried the latest type of London and North Western road, nor do I believe that a test made under such conditions can be in any way regarded as conclusive.

The whole of the four tracks between New York and Pittsbugh are signalled on the automatic (electro-pneumatic) system of the Union Switch and Signal Company. The signals are operated by compressed air controlled by electric circuits in the track. The line is divided into block sections about 1,000 or 1,300 yards long, a home and distant signal being placed at

commencement of every section. The arrangement is such that when a current is flowing along the track air is admitted to the mechanism operating the signals and the signals are pulled "off," *i.e.*, to the safety position. When, however, any engine or car is in the section the track current is short-circuited, the air valves are closed, and the signal returns to "danger." The principle of automatic signalling is good, but it is not easy to understand the advantage of splitting up the line into such short sections. The number of signals is bewildering, and it seems rather absurd to tell a driver who is, say, running at 50 or 60 miles an hour that the line is clear for no greater distance than 1,000 yards or so. The whole question of automatic signalling, and its suitability for English conditions, requires more consideration than it has hitherto received.

The Pennsylvania Railroad Company use cast iron wheels with chilled rims and flanges, not only on their freight trains, as is the general custom on all American railroads, but also for their passenger trains. The risk with these wheels is that the flanges are liable to be brittle and to break. If this happens a derailment is almost certain to occur. The advantage of these wheels is their cheapness. The manufacturing companies supplying them will always take back the old wheels at a good price, and break them up and recast them, so that the nett cost of the wheel to the railway company is very small, probably not more than 3 or 4 dollars.

I returned to New York at about 6 p.m.

Friday, October 17th.—I left New York at 8.45 a.m., in the private car belonging to Mr. J. N. Beckley, president of the Toronto, Buffalo, and Hamilton Railway, and president of the Pneumatic Signal Company of New York and Rochester. Mr. Beckley, on hearing that I was about to visit the States, communicated with me in England and most kindly arranged to make up a party of engineers and others for a tour to Albany, Buffalo, Niagara, Toronto, Detroit, Chicago, Washington, and back to New York, the trip to last about 10 or 11 days. In this way I was afforded an opportunity of visiting the places named and of seeing various matters of interest under the most favourable auspices. I was not disappointed, for nothing was omitted to make the trip successful and instructive.

The party at starting consisted of Mr. Beckley, General Eugene Griffin, late of the U.S.A. Corps of Engineers, and now vice-president of the General Electric Company of America, Mr. A. Spencer, director of the Railway Signalling Company of Fazakerly, Liverpool, Mr. W. Craven, of Craven Bros., Manchester, Mr. Hansel, vice-president of the Pneumatic Signal Company, and myself.

We travelled by the New York Central Railroad to Albany, arriving there about noon. The car was there detached from the train and placed in a siding, while we all went by electric car to Schenectady over the new high speed inter-urban line. This is a good specimen of the class of railway which is being constructed in many parts of the States. The distance between Albany and Schenectady is 17 miles, the population of the former being 100,000 and of the latter 50,000. Hitherto the inhabitants have been served by the New York Central Steam Railway, which runs between the two cities, and the electric railway has captured about two-thirds of the passenger traffic from the older line and has at the same time built up an additional traffic of its own. It now carries 3,700 passengers per day. The line connects with the tramways in Albany and Schenectady, so that passengers have the advantage of travelling to or from the centres of those cities without change of car. The usual service between the two places is a car each way every 15 minutes, but in the morning and evening the interval is reduced to 10 minutes. There is also an all night service, the cars running every hour after midnight. An express baggage car runs every hour and freight cars every 45 minutes. The schedule time between the centres of the cities is 45 minutes, including stops, and including at least three miles over the tram lines, on which the speed has to be low. This gives an average speed of 23 miles an hour, but the maximum speed is as high as 50 miles an hour. The fare is 25 cents for the single journey and 40 cents for a return ticket. Books of monthly tickets are sold at a reduced rate.

The line consists of two tracks laid on the public highway, of which they occupy about two-thirds, the remainder being a mere unmetalled roadway full of ruts. The railway is not fenced off, and the public have the right to walk or drive over it. But as the rails are laid on cross ties or sleepers and are raised above the surface of the roadway the public have little inducement to use the portion of the road occupied by the railway. The rails weigh 80 lbs. per yard and are of the usual T section, except in the city of Albany where the ordinary grooved tram rail is laid, which weighs 110 lbs. per yard and is of the girder section. The electrical equipment is on the overhead trolley system, the trolley wire being supported on span wires carried on wood posts. The power is transmitted from the power house at 10,000 volts (alternating three phase) which is transformed and converted in the sub-stations into a direct current of 550 volts in the trolley wire. The cars have four motors of 50 H.P. each and seat 50 passengers. The wheels have cast iron centres and steel tires with $\frac{3}{4}$-inch flanges and 3-inch treads, the small flange being necessary to permit of the cars running over the street railways in Albany and Schenectady.

The line cost 30,000 dollars per mile of double track, including equipment. The one objectionable feature of the railway is that it is laid on the public highway, and it is satisfactory to learn that the present tendency in America is to lay high speed lines of this class on land acquired for the purpose.

The cars are equipped with the Westinghouse direct air brake, the air reservoirs below the cars being charged at the sub-stations.

The works of the General Electric Company at Schenectady are very extensive, and equipped with all the most modern plant. They employ about 9,000 hands. The Company are giving particular attention to the development of the Curtis steam turbine, which differs in detail, though not in principle, from the Parson's turbine. The blades of the Curtis turbine are somewhat longer and thicker than those of the other, and are cut out of the solid steel disc, instead of being built on to the latter. I saw some most ingenious automatic tools at work, which have been devised for the purpose of cutting and shaping the blades. This method of construction seems to possess greater strength and durability than the other, but is probably more costly, though I have no figures as to this. Another peculiarity of the Curtis turbine, as manufactured by the General Electric Company for use with electric generators, is that it is fixed upon a vertical shaft, the turbine being below and the generator above, the weight of the shaft and of the machinery attached to it being supported upon oil, which is forced in under pressure below the end of the shaft, so that the latter revolves upon a film of oil. This arrangement o the machine economises space and makes the whole thing remarkably compact.

The party returned to Albany at 6 p.m., and was entertained at dinner by Mr. Coffin, president of the General Electric Company, who came from New York for this purpose.

Saturday, October 18th.—The car was attached to the train for Buffalo, leaving Albany at 8.15 a.m., and after a pleasant journey on the New York Central Railroad we arrived at Buffalo at 4 p.m., where we were met by Mr. Fisher, the superintendent of the Toronto, Hamilton, and Buffalo Railway. After a drive round Buffalo, the party was entertained at dinner at the Buffalo Club. After dinner I went to the power station at the Buffalo Electric Lighting and Power Company, where current is received from the Cataract Power and Conduit Company, a sub-company of the Niagara Falls Power Company, at 11,000 volts (three phase alternating) and is transformed or converted into currents of less voltage (alternating or direct) according to the needs of the various consumers. This is a most interesting place, the transformers and converters being very numerous, and only requiring two men to look after them.

Sunday October 19th.—The party went by train at 10 a.m. to Niagara, and after inspecting the low pressure pneumatic interlocking and signalling plant in the signal cabin at Suspension Bridge we went to the power house of the Niagara Falls Power Company and saw the celebrated turbines, &c. We were conducted

over the power station by some of the officers of the Company, and were given every opportunity of seeing all there is. Under its charter the Company has the right to take 200,000 H.P. from the falls. At present only one power station is at work with a capacity of 50,000 H.P., but a second station is nearly completed of the same capacity, both these being supplied with water by the same canal. The difference of level between the water in the river $1\frac{1}{4}$ miles above the falls and the river below the falls is about 200 ft. The power station is situated $1\frac{1}{4}$ miles above the falls, and is connected with the river by a canal 250 ft. wide, 12 ft. deep, and 1,700 ft. long. Parallel with this is a wheel pit 425 ft. long, 18 5 ft. wide, and 178·5 ft. deep. From the wheel pit a tunnel 6,890 ft. long, 18 ft. 10 in. wide, and 21 ft. high is constructed under the town of Niagara, and discharges into the river below the falls. It is of horse-shoe form throughout, is lined with brickwork, and at its lower end is plated with steel. In the sides of the canal are openings guarded by gratings, and from these steel penstocks 7·5 ft. in diameter conduct the water to the turbines in the wheel pit below. The turbines, of which there are ten now at work, are twin wheels, inverted, that is to say, the water enters them below and comes out above, and they work under a head of 136 ft. Each turbine has a capacity of 5,000 H.P. From the turbines hollow vertical shafts extend upwards to the generators above, which revolve at 250 revolutions per minute. The generators are two phase alternating current machines with revolving fields and fixed armatures, producing current at 2,200 volts pressure. A portion of this current is then transformed to 22,000 volts for transmission to Buffalo, the remainder being transformed to 11,000 volts for transmission to the sub-station two miles away, where it is stepped down for redistribution to the local factories. The most distant sub-station in Buffalo is 31·4 miles from the falls. The whole district between Niagara and Buffalo is being covered with manufactories, and there is little doubt that in a few years' time the two cities will become very important industrial centres.

On the Canadian side of the river the Canadian Niagara Power Company are now installing a plant of 100,000 H.P., and a third company, the Ontario Power Company, are also commencing work upon a similar station.

In the afternoon we visited the falls, and saw them from every point of view, a car of the International (Electric) Railway Company being placed at our disposal by the manager of the Company, who made every arrangement for our convenience. This railway is a combination of several different lines, including the one on the Canadian side of the falls and rapids. It has a total mileage of about 200 miles of double track. It commences in Buffalo, whence two main routes diverge, one a high speed line to Lockport and Olcott, on Lake Ontario, and the other to Niagara. The latter line crosses the river just below the falls by the steel arched bridge belonging to the Company, and recrosses it some distance below the whirlpool and rapids by the new suspension bridge recently erected, whence it returns to Niagara and Buffalo along the American side of the river.

We then returned to Buffalo by way of the Buffalo and Lockport line, which we joined at Tonawanda Junction, about half-way between Niagara and Buffalo. This is a high speed single track trolley line, between Buffalo and Lockport, with an extension to Olcott, the total mileage being about 35. The schedule speed on it is 27 miles per hour outside the city limits, and the maximum speed is 50 miles per hour. The round trip fare from Buffalo to Lockport and back is 75 cents. The cars have four 50 H.P. motors, and weigh 22 tons. Two 30 ton electric locomotives are also used upon this line to handle the freight service. These are capable of drawing trains of 650 tons at the speed of 10 miles an hour, and trains of 450 tons at 15 miles per hour. The locomotives have four motors of 165 H.P. each, making a total of 660 H.P. They are fitted with air pumps for braking purposes, and with special trolleys, which are controlled from the interior of the cab by means of pneumatic pressure.

We returned to Buffalo at 7 p.m.

Monday, October 20th.—We left Buffalo at noon, after inspecting the low pressure pneumatic signalling installation at the station, and arrived at Toronto at 4 p.m., travelling over the Toronto, Hamilton, and Buffalo Railway. This is a single track line, a portion of it being jointly owned by Toronto, Hamilton, and Buffalo Company and by the Canadian Grand Trunk. It forms a very useful connection between America and Canada, and probably has a prosperous future before it. It is in good condition and runs very smoothly.

Tuesday, October 21st.—I spent the morning examining the street railway or tramway system of Toronto, which is owned and operated by the Toronto Railway Company. This Company operates about 150 miles of line, including those in the suburbs. The Company has to pay to the city of Toronto an annual sum equal to 10 per cent. of its gross earnings, besides half the cost of the maintenance of the streets as well. In return for this onerous obligation it has received a 50 years' franchise.

The track is laid with a grooved rail in the city, the groove being 1½ in. wide, and outside the city the ordinary T rail is used. The speed in the streets is limited to six miles an hour by the local authorities, but outside the city speeds of 10 and 12 miles and more are attained. The speeds are lower than those prevailing in the States, resembling those usual on English tramways. The cars are wide (8 ft.), and the clearance between passing cars is small, the space between the tracks being only 3 ft. 6 ins. Both four-wheeled and bogie cars are employed, the former having two motors of 42 H.P. each, and the latter two motors of 50 H.P. each. Maximum traction trucks are used in some cases, but are not a success.

The rail joints are cast welded, and the rails are laid upon cross ties as is customary in America.

At 1 p.m. the party left Toronto, after inspecting the pneumatic interlocking and signalling plant at the station, and arrived at Hamilton at 4 p.m. Here we spent a few hours driving round the place, which is a fairly prosperous manufacturing town at the south-west extremity of Lake Ontario. We left at 6 p.m. and arrived at Detroit at 11 p.m.

The crossing of the Detroit River was interesting, the whole of the train being placed upon the steam ferry boat and transported from the east to the west side of the river with little delay. The boat has three tracks upon it, capable of holding three or four cars each, and the train was split up between them.

Wednesday, October 22nd.—The half-yearly meeting of the American Railway Association took place this morning at Detroit. This association embraces the chief operating officers of all the railways, Canadian, American, and Mexican, in the country. Each railway selects its own delegates, whose names are registered, and whose voting powers are laid down. The organisation is very complete, the headquarters of the association being in New York. Although the companies are not bound by the vote of the majority, yet practically it happens that the minority are usually compelled by circumstances to fall into line with the decisions arrived at, and subjects of the utmost importance are discussed and disposed of at these meetings. My host, Mr. Beckley, in his capacity of president of the Toronto, Hamilton, and Buffalo Railway, is a member of the Association, and introduced me to the president, Mr. Sullivan, of the Illinois Central Railway, who in turn introduced me to the members and invited me to be present during the sitting of the convention. In this way I became acquainted with the chief officers of all the railways, and received invitations from them all to visit all parts of the country, from Canada to Mexico, invitations which I regretted I could not then accept. The most friendly welcome was extended to me from all sides, and I had a most pleasant experience.

In the afternoon I went to inspect the street railways of Detroit, also one of the numerous high speed electric lines which radiate from this city, and the works of the American Car and Foundry Company.

The street railways at this place call for no special remark, beyond a note that they are among the best constructed of any that I saw in the States. They are laid with a grooved rail, and are operated on the overhead trolley system. The cars are mostly four-wheeled, with Dupont trucks with 8 ft. wheel base. The cars are noticeable on account of the very long overhang at each end, the total length of the cars being 33 ft., an arrangement which causes the cars to pitch a good deal.

Detroit is remarkable for its system of high speed electric interurban lines, there being nearly 400 miles of such lines measured as single track, in addition to 187 miles of street railway in the city. Most of these lines are single track with passing places, and all but one are under the control of the Detroit United Railway Company, the one exception being the Detroit, Ypsilanti, Ann Arbor, and Jackson Railway, which is 75 miles long. The lines controlled by the Detroit United Railway Company are :—

The Detroit and Pontiac Railway, 36·52 miles.

The Detroit and Rochester and Lake Orion Railway, 85·31 miles.

The Detroit and North-Western Railway, 58·77 miles.

The Wyandotte and Detroit River Railway, 10·75 miles.

The Detroit and Port Huron Shore Line Railway, 109·7 miles.

The service to the distant points is hourly, but to the nearer places a half-hourly service is given. The capitalisation of these lines amounts to about 40,000 dollars a mile, half of which is represented by bonds. The earnings per mile of track per annum may be taken on the average as 3,500 dollars.

The population of Detroit is 285,704, and that of the district served by the interurban lines is about 150,000.

As this was one of the first places to adopt railways of this class, there is a great variety of construction and rolling stock in existence, but the engineers are gradually introducing a uniform standard of track and equipment. Many of the lines are laid along the public highways, but the tendency here as elsewhere is to lay all new lines on private lands acquired for the purpose. All the lines carry freight, but the freight and passenger services are kept distinct and separate.

The schedules of speeds on all the lines are similar, the average speed being about 20 miles an hour, which, allowing for the number of stops and the restrictions inside the city, necessitates running speeds of 40 and 50 miles an hour. Four motors per car have been found here, as elsewhere, more satisfactory than two, and the latest cars have four motors of 60 H.P. to 75 H.P. each, and are capable of seating 50 to 60 passengers ; these cars are 50 ft. long over all, and weigh 30 to 35 tons.

I had a trip on the Detroit and Port Huron Railway for a few miles, as far as the sub-station at Roseville. The main power station is situated about half way between the terminals, from which high tension alternating current of 16,000 volts is distributed to the six sub-stations. The trolley current is 600 volts direct. There are 14 passenger cars and three 25-ton freight cars in use on this line. The wheels are 36 in. in diameter, and have flanges $\frac{7}{8}$ in. deep, and treads $2\frac{3}{8}$ in. wide.

The rails are mostly 60 or 70 lbs. per yard, some being in lengths of 60 ft., and the tracks are in fairly good order. The switches have double spring tongues, and the frogs are of the spring type. In some cases aluminium is used in place of copper for the main distributing wires.

All the lines are operated by means of telephones, which are located in cabins or booths at intervals along the route, the train despatcher having his head office at some central point. On arriving at one of these places the conductor or motorman has to go to the telephone to ascertain his orders, and both conductor and motorman must be present and hear the orders

given and repeated. No car must leave one of these spots without an order from the train despatcher. The cars travel about 300 miles a day.

The investigation of these lines at Detroit was most interesting and instructive.

We then went to the works of the American Car and Foundry Company, and saw some of the big 50-ft. pressed steel freight cars being built. These works are very extensive, and are capable of turning out 40 to 50 complete steel cars of various sizes per day. The presses are operated by hydraulic power and the machine tools by electricity. I was glad to have an opportunity of seeing the construction of the large steel cars, which are now such a marked feature upon American railways.

At 8 p.m. we left Detroit for Chicago, the party now consisting of Mr. Sullivan, president of the American Railway Association and assistant vice-president of the Illinois Central Railway; General Griffin; Mr. Hansel; Mr. Wilson, President of the "Railway Age"; Mr. Spencer, and myself. Mr. Beckley had to return to his home in Rochester, but his car was still at our disposal, and we all slept on board it.

Thursday, October 23rd.—We arrived at Chicago at 7 a.m.

At 10 o'clock I called on Mr. Roach, president of the Union Traction Company, Chicago, and Mr. C. Buckingham, president of the North-Western Elevated Railroad, Chicago, to both of whom I had letters of introduction. These gentlemen promised me every facility for seeing their respective railways.

Several high speed electric inter-urban railways start from Chicago, and in the afternoon I went for a trip on one of them, viz., the Aurora Elgin and Chicago, which is the most recent of these lines. At present a speed of 60 miles an hour is attained, and experiments up to 100 miles an hour are to be made early next year.

This line has 21 miles of double track, and two single track branches of 14 and 16·5 miles respectively. On the latter there are several long sidings, which bring the total mileage of the whole line, measured as single track, up to 82 miles. The population per mile of track, exclusive of Chicago, is 14,000. The track is laid with 80-lb. T-rails in 60-ft. lengths, the conductor rail being 100-lb. T-rail. The ties are placed 2 ft. apart from centre to centre. The transmission voltage is 26,400 volts, and the working current is 600 volts. The maximum distance for transmission is 35 miles. The cars weigh 40 tons and are 47 ft. long, with a seating capacity of 56. The wheels are 36 ins. in diameter, and have M.C.B. flanges and treads, viz., $1\frac{3}{8}$-in. flange, and $3\frac{3}{8}$-in. tread. The schedule speed at present is 40 miles an hour, including stops, and the maximum speed is 60 miles an hour. I travelled at the latter speed for some distance, and the running of the car was smooth and comfortable, it being in fact difficult to realise that one was moving at so high a speed. The track, which is substantially constructed, is, however, so new as to be hardly in a condition for such high speed. The line is laid on the Company's "private right of way," *i.e.*, on land which has been purchased for the purpose.

The cars have four motors of 125 H.P. each, and reach full speed in 30 seconds, the acceleration being at the rate of 2 miles per hour per second. They have Christensen non-automatic air brakes and hand brakes.

The high tension transmission wires are of aluminium stranded, each wire containing eight strands.

I visited one of the sub-stations of this line, where are situated the transformers and converters for converting the high tension transmission current to the direct current of 600 volts. The main current is controlled by oil switches which are operated by small motors, the current for which is supplied from local batteries. This seemed to me to be as safe a method of handling these high potential currents as can be devised.

Friday, October 24th.—At 9.30 a.m. I went with the engineer, Mr. Murphy, to examine the Chicago Union Traction Company's system of Surface lines or tramways, which include all the tramways in the city, amounting to about 210 miles of double track. Of this total about 24 miles are operated by cable traction, the remainder by trolley. As usual in the States there is a variety of rails used in the streets, but the grooved rail is supplanting the others. The track is in indifferent order, and the streets are, generally speaking, neglected and uneven. Two, three, and four cars are allowed to be coupled together and to run as trains through the streets, thus occupying a great deal of the roadway. The speed down town is limited to 6 miles an hour; elsewhere it is anything up to 15 and 18 miles an hour. Some cars are four wheeled with two motors of 35 H.P. each, others have two bogie trucks with more powerful motors. The maximum traction trucks which are fitted to some of the cars are not considered satisfactory. The electric cars have the direct (non-automatic) Christensen air brake, while the cable cars have the slipper or track brake. The cars are single deckers, double decked cars being unknown in America.

The Union Traction Company have five power stations, of which the principal one contains one 800 kilowatt Siemens-Halske direct current generator, and five 1,500 kilowatt generators of the same make and nature. Another has one 1,500 kilowatt generator, and three 800 kilowatt generators; the current in all instances is direct, and the voltage 550.

The cars are warmed in winter by means of small stoves placed in the centre of each vehicle, and they are fitted with life guards of various types, and of little merit.

In the afternoon I was taken by Mr. Hedley over the North Western Elevated Railway, which in construction is similar to the Elevated roads of New York and Boston. There are four of these elevated lines in Chicago, viz., the South Side Elevated Railroad, the Metropolitan West Side Elevated Railroad, the Lake Street Elevated Railroad, and the North Western Elevated Railroad, all similar in design, but radiating in different directions. In the centre of the city there is a rectangular loop (double track), and all the elevated lines converge on this, entering it at different corners. This loop, which is of considerable length, surrounds the business section of the city, and enables the trains of each line to circle round and reverse their direction without any switching—at the same time affording a frequent service for local passengers who may want to go from one part of the district enclosed by the loop to another. On the loop the trains travel on the left hand track instead of on the right, as is usual in America. The reason for this is not clear, but it is said to be more convenient for the trains which have to cross each other at the junctions. In consequence of the loop serving so many lines, the congestion of the trains upon it is at times very great, the trains almost touching one another as they pass round.

On the North Western Elevated line there are four tracks, two for express and two for local traffic. The trains consist of four or five cars, viz., one motor car and three or four trailers. The motor cars for the four car trains have two motors of 160 H.P. each, and those of the five car trains have four motors of the same horse power. The car trucks are bogies, of Hedley's patent cast steel pattern. The rails weigh 80 lbs. per yard, and the conductor rail 50 lbs. Inside check rails and outside wheel guards are fixed throughout the track. The speed varies according to the number of stops to be made, and on the express tracks is 25 or 30 miles an hour. But all trains have to slacken speed to 8 miles an hour at the sharp curves, some of which have radii of 90 ft. All curves are compounded.

The line is operated by direct current at 550 volts.

At the junctions and important stations signal cabins exist with mechanical interlocking plants, the arrangements of which seem to be well carried out.

Saturday, October 5th.—I spent the morning with Mr. Sullivan, assistant vice-president of the Illinois Central Railroad and president of the American

Railway Association, who took me to the Company's workshops and showed me their large engines and cars, which are here repaired. The Company does not build its own engines, but executes its own repairs, for which purpose the shops are very completely equipped. Some figures were given me of the performances of the heavy engines now employed by the company, which are instructive, as they are based on trial trips extending over 10,000 miles—made by four engines of different types over the same section of the line—and lasting from 94 to 124 days. The number of freight cars per train averaged from 36 to 50, and the gross tonnage per train from 1,076 to 1,511. Each engine made 96 trips, and the total cost to haul 10,000 tons (of 2,000 lbs.) one mile varies from 1·86 dollars to 2·02 dollars.

At 8.30 p.m. I left Chicago for St. Louis.

Sunday, October 26th.—I arrived at St. Louis at 8 a.m., where I was met by several of the principal railway officers, who took me to see the electro-pneumatic signalling installation at the entrance to the station. The arrangement of the station yard here is peculiar. The tracks are laid out in the shape of an equilateral triangle, with the station at one angle. All trains from either direction run past the station on the side of the triangle subtending the station and are then backed into the station, so that the engines are always at the right end for the trains to depart from the place, thus avoiding all switching of the engines. The tracks are laid out in a very symmetrical fashion. as is usual at all the new stations in America, and the interlocking is skilfully carried out. The trains entering the station are controlled by the brakesman, who stands on the end platform of the leading car and regulates the speed by means of the air brake.

The station is very large, the train shed containing 32 tracks, all available for the arrival or departure of trains. The waiting rooms, booking halls, lavatories, women's room, &c., &c., are exceedingly comfortable, and furnished and warmed in the elaborate manner customary in these new large terminal stations in the States. In stations such as this the Americans are far ahead of anything we can show in England. The warming and lighting of these stations are most carefully attended to, so that it is almost a pleasure to have to wait for one's train, instead of misery as is so often the case elsewhere.

The station is the property of an independent company formed for the purpose by the several lines running into St. Louis, an arrangement similar to that at Boston and other places, where more than one railway enters a city.

After breakfast at the club I was taken for a drive through the grounds of the Pan-American Exhibition, which is to be held here in 1904. The buildings are in a very forward state and the preparations are on a colossal scale, the intention being to make this the biggest thing of the sort ever attempted. The buildings are of wood, without a particle of steel or iron in any part, and are therefore peculiarly liable to fire. But as the woodwork is to be covered with plaster facings and mouldings, so as to resemble stone or marble, they will to a certain extent be protected.

At 8 p.m. I left St. Louis for Washington *viâ* the Vandalia (single track) line, which is practically the property of the Pennsylvania Railroad. Though the track was not quite of the high standard of the main line, it afforded very smooth running.

Monday, October 27th.—The train reached Pittsburgh at 7.15 a.m., and after a short halt proceeded to Washington, where I arrived at 7 p.m., after a very comfortable journey. At one time my train was switched across on to the wrong track and travelled on it for several miles at high speed. This was done because the eastbound track, on which we should have been, was occupied by coal trains. The scenery approaching Washington is attractive.

Tuesday, October 28th.—General Griffin, who, as a former engineer officer of the United States Army, was well acquainted with the place, showed me all the sights. I called on Mr. Moseley, secretary of the Interstate Commerce Commission, and made some enquiries from him about the use of automatic brakes on freight trains. I had been surprised on Monday, when descending

the Horse-Shoe Curve on the Pennsylvania Railroad, to see the freight trains being handled by means of the hand brakes and not by the air brakes. This is a dangerous practice, as the brakesmen, of whom there are four or five on each train, have to run about on the tops of the cars, in order to apply or release the brakes, and seems to be contrary to the law, which prescribes the use of air brakes on all trains engaged in Interstate traffic. I had been informed that the Pennsylvania Railroad Company have found a difficulty in operating trains down this incline by means of the air brake, because, if the driver is not skilful in the use of the air brake, there is a risk that he will exhaust all the air in the reservoirs before reaching the bottom of the incline and will then be unable to control his train. The Company, therefore, argue that it is safer to depend on the hand brake and not on the air brake. Mr. Moseley did not agree with the Company on this point, and said that the matter was engaging the attention of the Commission. He said that the companies out West were able to work their trains down the slopes of the Rockies with the air brakes, and could not, in fact, do without them, and what they could do the Pennsylvania Company could also do.

General Griffin obtained an introduction for me to President Roosevelt, who received me very pleasantly, and honoured me with a few minutes informal conversation in his study.

I visited the Capitol, which, though a fine building externally, is not particularly impressive inside.

The Library of Congress, which is about a quarter of a mile from the Capitol, is a handsome building, and the large octagonal reading room is grand. The library contains over a million books and pamphlets, and has a capacity at the present time of 2,085,000. This can be increased to 4,500,000 by the addition of more shelves. The arrangements for the comfort and convenience of readers are admirable, and the system of registering and storing the books is excellent. Some very ingenious mechanism has been devised for conveying the books to and from the book stacks, which are outside the reading-room, by means of which a reader can obtain any book he requires in a few minutes. There is also a tunnel connecting the library with the Capitol, with a book-carrying apparatus operated by electricity in it, whereby any book desired by a Member of Congress, can be despatched to the Capitol immediately after the receipt of the telephonic message demanding it.

The tramway system of Washington has the centre slot or conduit mode of construction with grooved rails, and possesses the best track of any I saw in America. The streets also are well paved and cleaned, and Washington was the most attractive city I saw. It is entirely residential, and not commercial or industrial.

Wednesday, October 29th.—I left Washington at 9 a.m., via The Baltimore and Ohio Railway as far as Philadelphia. Here the car was transferred to the Philadelphia and Reading Railway, and I was invited to examine the pneumatic low pressure interlocking installation at Wayne Junction, there being 64 levers in the cabin. Automatic block signalling is also in force at this junction, and from here to New Jersey City. The signalling arrangements at Wayne Junction seem to be good. The automatic block signals were altogether distinct from the signals operated from the cabin (called in America "interlocking signals"), and before a driver is authorised to proceed on his journey, he has to make sure that the automatic signal, as well as the interlocking signal, is at "clear." This seems to have some advantages over the usual system of employing semi-automatic signals, *i.e.*, signals partly controlled by the track circuit and partly by the signalman. Automatic indicators working in conjunction with the track circuit are provided in the cabin to indicate to the signalman the position of any train or engine in the neighbourhood. After this I was conveyed by special train to Jersey City, and arrived in New York at 5 p.m. It was brought to my notice that whereas the Philadelphia and Reading Railway have the Hall automatic signals, the position of which is normally at danger, the New Jersey Central Railway has the electro-pneumatic system, in which the normal position of all signals is "clear." Having regard to the fact that with the normal danger

system it is necessary, in order to save delay, for each signal to drop to the safety position sometime before a driver reaches it or even sees it, I am unable to see much advantage in the system, especially as it requires additional mechanism and introduces additional complication.

Thursday, October 30th.—I said farewell to my many friends in New York, who had done so much to make my stay in America pleasant and interesting. At 11 p.m. I went on board the s.s. "Celtic," as we were to sail early the following morning.

Friday, October 31st.—Sailed at 6 a.m.

Saturday, November 8th.—Arrived at Liverpool 3 p.m. after an absence of seven weeks and two days.

H. A. Y.

London, December 5th, 1902.

P.S.—I collected many plans, books, pamphlets, and other information, of interest. I attach a list of these, which are at Richmond Terrace.

THE BOSTON SOUTH STATION.

Statistics.

Station dedicated, December 30, 1898 ; operated, January 1, 1899.

Trains of N. Y., N. H. & H. R. R. Co., Plymouth and Midland Divs., entered January 1, 1899.

Trains of Boston & Albany Railroad Company entered July 23, 1899.

Trains of N. Y., N. H. & H. R. R. Co., Providence Division, entered September 10, 1899.

Land.—Area, about 35 acres ; covered by buildings, about 13 acres.

Main Station.—Length, maximum, 850 feet ; width, maximum, 725 feet.
Length, average, 765 feet ; width, average, 662 feet.
Area, 506,430 sq. feet. Area awnings, outside buildings, 46,000 sq. feet.
Area of connecting roofs, 17,500 sq. feet.
Total length of buildings on street front, 3,300 feet.
Height from sidewalk to top of eagle, 135 feet ; to top of flag-pole, 200 feet.
The clock dial in tower is 12 feet in diameter.
The granite eagle is about 8 feet high, 8 feet wide, and weighs about 8 tons.

Midway.—Area, 60,000 sq. feet.

Waiting Room.—Length, 225 feet ; width 65 feet ; height 28½ feet.

Baggage Rooms.—Outward, 530 × 26 feet ; inward, 470 × 26 feet.

Express Buildings.—Length, 712 feet ; width, 50 feet.

Power Buildings.—Length, 569 feet ; width, 40 feet.

Train Shed.—Length, 602 feet ; width, middle span, 228 feet.
Height over all, 112 feet ; two side spans each 171 feet.
Total width ... . 570 feet.
Trusses, cantilever and 60 feet centre to centre.

Tracks.—Total length, about 15 miles ; length under roof, 4 miles.
Total number entering station, 32 ; 28 on main floor and 4 in the shape of two loop tracks in subway (2 feet below level of mean high water in Boston Harbour).
Number through throat in yard, 8 for main floor ; 4 for subway.
Total weight of rail, 2,500 tons—100 lbs. to the yard.

Switches, double slip, 34	equivalent to 255 single switches.	Frogs, rigid,	173
Switches, single, power, 51		Frogs, movable,	68
Switches, single, hand, 52			241
137.			

Car Capacity.—344 sixty-five foot cars on main floor against platforms ; 252 of same under roof.
60 forty-foot cars in subway.
116 cars in express yard ; 62 mail and express cars against platforms.
93 cars on other tracks.

Total, 613 cars.
Seating capacity of passenger cars that can be placed against platforms of Station, 28,104.

Interlocking.—Semaphore signals, high type,	109	Levers in Tower No. 1,	143
Semaphore signals, dwarf,	28	Levers in Tower No. 2,	11
	137	Levers in Tower No. 3,	11
			165
Signal lamps, electric	182	Signal bridges	9

Complete Lever movements in Tower No. 1, 28,450 per day.
Movements including indications { switch, 18,970 ; signal, 25,294 } 44,264 per day.

Power Plant.—Entire capacity, 2,000 H.P., with room for 50 per cent. additional installation.
Daily capacity of Ice Plant, 25 tons.
Daily capacity of Gas Plant, 120,000 cubic feet.

Movements.—Daily, through yard, about 4,000.
Regular week-day trains, summer schedule, 801.
Regular week-day trains, winter schedule, 770.
Cars to and from station, daily, 3,000.
Mail and express cars to and from express building daily, 150 to 400

Restaurant.—Seating capacity of dining rooms,	315
Seating capacity of lunch room,	185
Total seating capacity ...	500

APPROXIMATE AMOUNT OF BUSINESS HANDLED:

25,000,000 passengers annually.
2,000,000 pieces of baggage annually.
350,000 parcels in Parcel room annually.
150 tons of U.S. mail daily.
13 tons of outward papers daily.
50 tons of inward N.Y. papers, Sunday.

2,500 persons employed at Terminal, including office forces of the different railroad and express companies, trainmen, and Railway Mail Service employés.

IN CONNECTION WITH THE STATION THERE ARE:

250 arc lights.
7,047 incandescent lights; of these
1,200 in main waiting room.
20 water meters.
29 storage vaults.
215 office rooms.
1,000 window shades.
200,000 lbs. sash weights.
150 Pintsch gas connections.
56 steam heat connections.
48 air-brake test connections.
11 steam boilers.
4 electric generators, 225 K.W.
1 motor generator.
50 electric motors.
10 compressors.
17 steam engines.
19 heating and ventilating fans.
1 travelling crane.
34,100 sq. feet (about ¾ acre) mosaic floor.
13 steam pumps.
2 draft fans.
25 electric elevators.
50 toilet rooms.
207 water closets.
6 shower baths (for trainmen).
143 set bowls.
26 sinks.
36 ticket windows (inc. subway).
90 baggage room doors.
71 express building doors.
78 clocks, electric self-winding.
3 fire alarm boxes, and
21 auxiliary stations.
1 watchman's time detector, and
33 registering stations.
31 fire risers, with 99 outlets.
50 miles piping.

LIST OF PLANS, BOOKS AND DOCUMENTS

COLLECTED BY COLONEL YORKE DURING HIS TRIP TO AMERICA. 1902.

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1. Standard plans and specifications of permanent way work, New York Central Railroad.
2. Standard plans and specifications of permanent way work, Pennsylvania Railroad.
3. Standard plans of track construction, New York street railways, Brooklyn street railways, and Boston Elevated railway.
4. Contract drawings and specifications, Rapid Transit Subway, New York.
5. Detailed descriptions of numerous Interurban Electric High Speed railways. (2 vols.)
6. Descriptions of the Boston South Station, and the mechanical equipment of the same.
7. Master Car Builders' Dictionary.
8. Proceedings of the Master Car Builders' Association, 1902.
9. Massachussets Railroad Commissioners' Report, 1902.
10. Descriptions of the various types of engines built at the Baldwin Locomotive Works, Philadelphia.
11. Various leaflets describing:—Electro-pneumatic automatic signalling and interlocking plant; Electric semaphore; Automatic air and steam pipe coupling; Friction draft gear; Newell's magnetic brake and car-heating apparatus; Westinghouse-Parsons steam turbine.
12. Modern Locomotives, being a description of typical American and European locomotives.
13. Standard Rule Books (signalling, block working, &c.) of the American Railway Association.
14. Description of the Curtis' steam turbine.
15. An address on Railway Management and Operation, by A. W. Sullivan, Assistant Vice-President, Illinois Central Railroad.

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